APPENDIX A

MONITORING PLAN FOR DENNY WAY SEDIMENT CAPPING

ATTACHMENT B

MONITORING PLAN
FOR DENNY WAY SEDIMENT CAPPING

Objectives

Environmental monitoring for the project involves both short term activities needed for cap placement plus longer term activities needed to document how well the cap functions. The strategy for long term monitoring is to do more intensive monitoring the first few years after capping and then decrease the frequency over time as appropriate. It is proposed that a five year monitoring plan be adopted at this time and that future monitoring requirements be finalized as part of a five year review process.

There are six main objectives associated with the monitoring program as listed below. A summary of the sampling activities and schedule are provided in Table 1 and sampling stations are shown in Figure 1.

OBJECTIVE 1: Insure that water quality standards for dissolved oxygen are maintained during cap placement.

OBJECTIVE 2: Guide and document the sediment cap placement and thickness.

OBJECTIVE 3: Document how well the cap functions to isolate contaminated sediments from migrating upwards into the cap.

OBJECTIVE 4: Identify whether chemicals accumulate in the surface of the cap such that they indicate a need for any additional specific toxicant source control work upstream in the Denny Way collection system.

OBJECTIVE 5: Determine the amount and type of benthic recolonization that occurs in the capping area.

OBJECTIVE 6: Review and evaluate the monitoring data to determine that (1) the cap is functioning as expected and (2) whether further actions are warranted in the capped area..

Water Column Dissolved Oxygen Level

Water column samples will be collected immediately before and after spreading the first barge load of sand to insure that dissolved oxygen levels are above the lower limit of 5.0 mg/liter. The sampling site will be located down current from the capping site and at the edge of a 300 foot dilution zone. Samples will be taken at the surface, at mid-depth, and at one meter above the bottom. Water column sampling will continue for the first three barge loads and this data will be evaluated to see if there is need to continue further monitoring. If there is no indication of a potential dissolved oxygen problem due to cap placement then monitoring will be suspended.

Cap Placement and Thickness

Bathymetric surveys will be used to document cap placement and thickness. These surveys will be conducted by the Army Corps of Engineers using electronic depth recording and navigation equipment. Surveys will be made before, during, and shortly after cap placement. The differences in water depth measurements will be translated into cap thickness. In addition, a diver survey will be performed to help verify cap thickness through the use of bottom stakes. An independent check on cap thickness will also be obtained when sediment cores are collected and processed during the post-cap monitoring discussed in the next section.

Three follow-up surveys of cap thickness will be conducted within the first five years as summarized in Table 1. These may be either electronic bathymetric surveys or diver surveys. The first two follow-up surveys will be conducted at approximately 12 and 24 months after cap placement to see if there are any obvious differences in cap thickness. The third survey will be conducted either after 60 months or perhaps sooner if there are exceptionally large storms that occur prior to 60 months. An analysis of each years data will be included in a report and discussed during both the annual review and the 5 year review. Decisions about when to conduct further bathymetric or diver surveys beyond 60 months will be made in conjunction with Ecology, DNR, EPA, and the Corps of Engineers during the five year review process.

Isolation of Contaminants

Sediment cores will be used to determine if there is any vertical migration of chemicals up into the cap material. A total of three coring stations will be established as shown in Figure 1. These coring stations provide spatial coverage across the cap and are intentionally located away from other sampling stations so that any potential release of contaminated sediment from the cores will not effect other surface sediment sampling stations.

One core will be collected from each of the three stations. Each core will extend completely through the sand cap and into the underlying contaminated sediments at least one foot. As shown in Figure 2, a total of five (5) 6-inch long sections will be retained as samples for chemical analysis.

Four (4) of the 6-inch sections will be taken from above the interface and one (1) 6-inch section will be taken below the interface. Because mixing can occur around the interface due to the physical process of capping, it is important to leave a space of at east one inch above the interface before taking the first sample. The exact distance will be determined after inspecting the interface of each baseline core, but will remain the same for future cores.

Sediment cores required to establish baseline data will be collected as soon as practical within one to two months after cap placement. All five sections of each baseline core will be analyzed for metal and organic priority pollutants including all of the routine Ecology sediment quality chemicals. Future core samples will be collected adjacent to the baseline stations to allow comparison of data. Five sample sections will be collected for each core, but initially only the first section above and below the interface will be analyzed for those chemicals found in the underlying contaminated sediments to determine whether any migration is evident. If migration appears evident then sections further up the core will be analyzed to determine how far chemical migration extends into the cap. Decisions about whether to analyze additional sections will be made within the storage times established under the Puget Sound Protocols.

Evaluation of vertical migration in the bottom of the cap will be limited to only chemicals that were present in the underlying sediments. Data will be normalized to dry weight to allow comparisons. Vertical migration from the cap surface downward will be evaluated if there is evidence of significant chemical accumulation on top of the cap based on surface sediment samples. Also, a direct measure of cap thickness will be made and compared to the thickness indicated by the bottom depth surveys.

The schedule for core sampling will be every year for the first three years, which yields samples at about 1-2 months (baseline), 14 months, and 26 months after cap placement. Sampling frequency beyond 26 months will be extended to alternate years and yield a sample about 50 months after cap placement. An analysis of each years data will be included in a monitoring report and the results discussed during an annual review plus a 5 year review. Decisions regarding the frequency of core sampling beyond 50 months will be made in conjunction with Ecology, DNR, EPA, and the Corps during the five year review process scheduled for 1995.

<u>**Surface Contamination of Cap**</u>

Accumulation of surface sediment contamination will be evaluated by collecting and analyzing samples from the five stations shown in Figure 1. Samples from the four subtidal stations will be collected with a Van Veen grab sampler. A stainless steel "cookie cutter" will be used to collect the top 2 cm of sediment from three replicate samples per station. These subsamples will be composited, and then analyzed for priority pollutant metals and organics including all the routine Ecology sediment quality chemicals.. The intertidal sample will be collected with a surface sampler at low tide. Data for all stations will be normalized to dry weight for comparison between stations and years.

Chemistry data will be compared to the baseline data and each previous years data to determine whether a change has occurred. If significant accumulation has occurred there will be an evaluation of upstream sources to identify sources that need to be reduced. Data from the intertidal sample will provide a link between conditions on the cap and those immediately in front of the outfall.

The schedule for surface sediment sampling will be every year for the first three years which will yield samples at about one to two months, 17 months, and 29 months after cap placement. It is anticipated that subsequent sampling for surface chemistry would be extended to alternate years which would yield a sample at about 53 months. An analysis of each years data will be included the monitoring report and discussed at both the annual review and the 5 year review. Decisions about the frequency and extent of surface sediment sampling beyond 53 months will be made in conjunction with Ecology, DNR, EPA, and the Corps of Engineers during the five year review process in 1995.

Benthic Recolonizaton

The primary method of evaluating recolonization of the sediment cap will be to obtain taxonomy data from surface grabs collected at the two north and south stations shown in Figure 1. These stations were selected to provide a general representation for the type of recolonization that occurs over the majority of the capping site. The first sampling will occur in August 1990, which is about five months after cap placement. Size of biota is expected to be small the first year so these samples will only be collected and stored at first and a decision about analysis made later. A Van Veen sampler will be used to collect five replicates per station and samples will be processed according to Puget Sound protocols. In the second year, benthic taxonomy samples will be screened through a standard 1.0 mm mesh and all organisms identified to the lowest practical taxonomic level (preferably to species). The single intertidal station will be sampled using standard intertidal methods.

Table 1 shows the schedule for benthic taxonomy sampling at yearly intervals for the first three years which will yield samples at about 5 months, 17 months, and 29 months after cap placement. Subsequent taxonomy sampling is anticipated to be extended to alternate years for a period and would yield a sample at about 53 months. Decisions about taxonomy sampling beyond 53 months will be determined in conjunction with Ecology, DNR, EPA, and the Corps of Engineers during the five year review process in 1995. An analysis of each years data will be included a monitoring report and then discussed at both the annual review plus the 5 year review. This recolonization analysis will involve comparing each years data to the previous years data and at the end of 5 years to an appropriate reference station.

A video camera survey (either diver operated or remote control) will be performed during the first year as a test to aid in the collection of supplemental biological information. This video camera survey will be conducted to inspect the cap surface to identify the presence of larger biological organisms, including presence of shrimp holes. A series of video transacts will be run parallel to shore to provide biological information on various depth contours in the range from 20 to 60 feet of water depth. Also, observations of the physical shape of the cap can provide information on the proficiency of the capping operation. Results of the preliminary video survey will be used to decide whether the video survey should be continued in future years.

The REMOTS photo sampler will be tested during the second year in place of the video camera survey as a method for obtaining supplemental biological information. The REMOTS survey will consist of taking sediment profile photographs over a grid of stations. Each photograph is about 15 cm wide and may be up to 15 cm high depending on how deep the camera prism penetrates into the surface of the sediment cap. Photographs will be analyzed for the following: 1) Uniformity of capping material across the site, 2) Presence and depth of any apparent "Redox Potential Discontinuity", 3) Infaunal successional stage, 4) Organism-sediment index, and 5) Other biological information such as the linear density of polycheate and/or amphipod tubes at the interface, plus signs of bioturbation. Results of the initial REMOTS survey will be used to decided whether REMOTS should be continued in subsequent years.

Review and Evaluation Process

A review process will be conducted on a regular basis to evaluate the monitoring data and determine if the cap is functioning as expected. To help facilitate this review, a monitoring report will be prepared that presents and analyzes the data. The monitoring report will be produced once each year that new monitoring data is obtained. Table 2 provides an outline of the topics to be addressed in the monitoring report.

Each monitoring report will be distributed to DNR, Ecology, EPA, the Corps of Engineers, and other interested groups. An annual meeting will be held to discuss and evaluate the report and conclusions. A major monitoring review will be conducted after 5 years and will include discussions about monitoring needs beyond 5 years. These discussions will consider whether the cap is functioning as expected and what contingency actions might be warranted if the cap is not functioning as expected, including whether resulting conditions at the cap surface warrant further action.

Table I. Summary Schedule of Monitoring Activities for Denny Way Capping

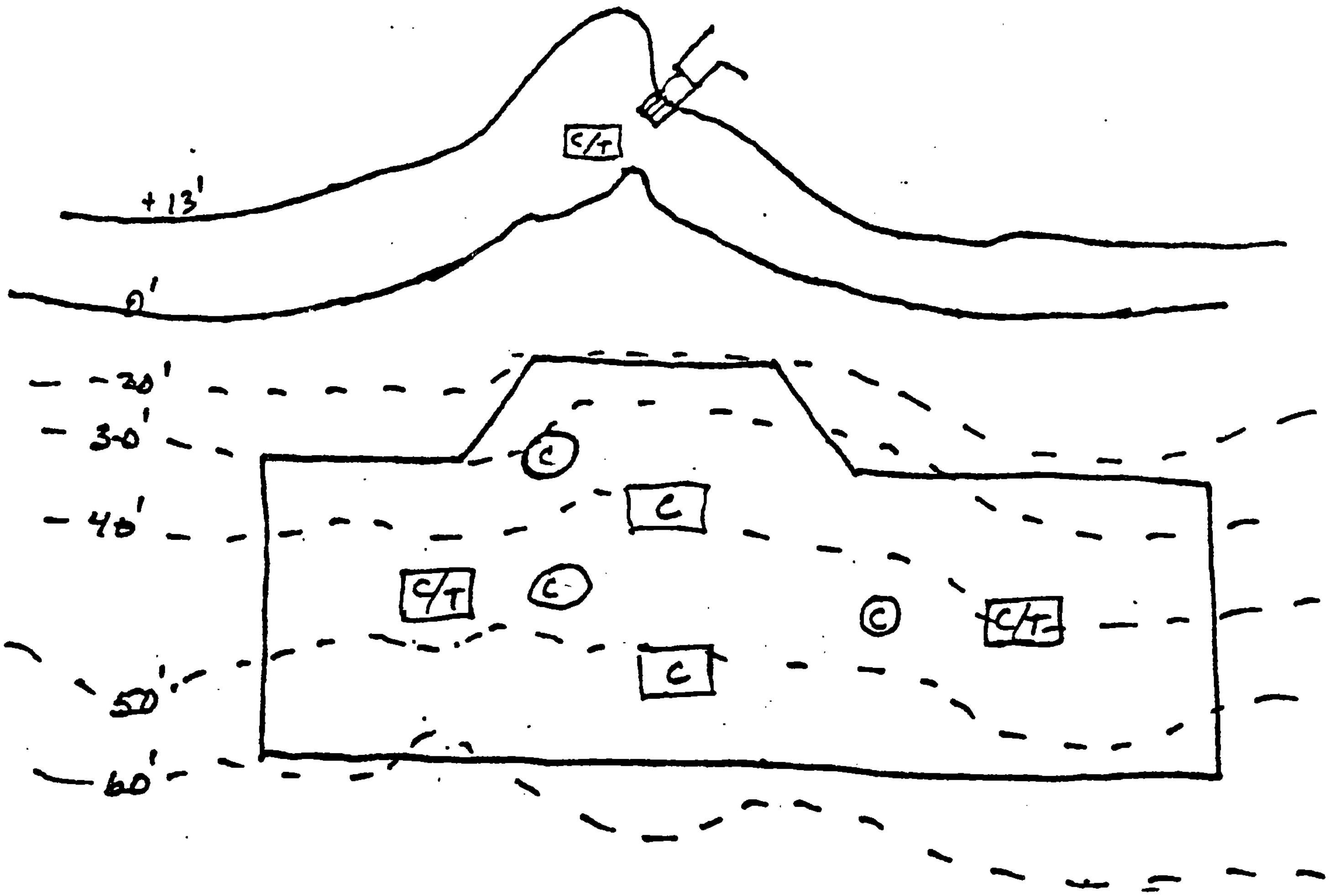
	Construction	Post Cap Monitoring										
		Five Year Plan Confirmed						To Be Established				
	1990	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
•Water Column Samples 1-station (3 dumps min)	X											
•Bathymetric Surveys Diver Survey	X X		X^c	X^c		X—	—X^c					
•Sediment Cores for Chemistry 3-stations (5 depth segments)		X^a	X	X		X					?	
•Surface Grabs for Chemistry 5-stations (top 2 cm)		X^a	X	X		X					?	
•Surface Grabs for Taxonomy 3-stations (5 replicates)		X^b	X	X		X					?	
•REMOTES Photographic Survey (evaluation			X									
•Video Camera Survey		X										
•Monitoring report for given year		X	X	X		X						
•Monitoring review meetings		X^d	X^d	X^d		X^d						
•Five year project review							X					X

a) Baseline sampling will be conducted as soon as practical within the first two months after cap placement.

b) First year taxonomy samples will only be stored and a decision about the need fc analysis made at a later date.

c) One of the survey methods will be used within the indicated time period.

d) Meetings may be held within the first two months of subsequent year.



 = Core sample station for chemistry analysis.

 = Grab sample station for surface sediment chemistry.

 = Grab sample station for surface sediment chemistry and taxonomy of benthic organisms.

Figure1. Sampling station locations for sediment cores and for surface grab samples.

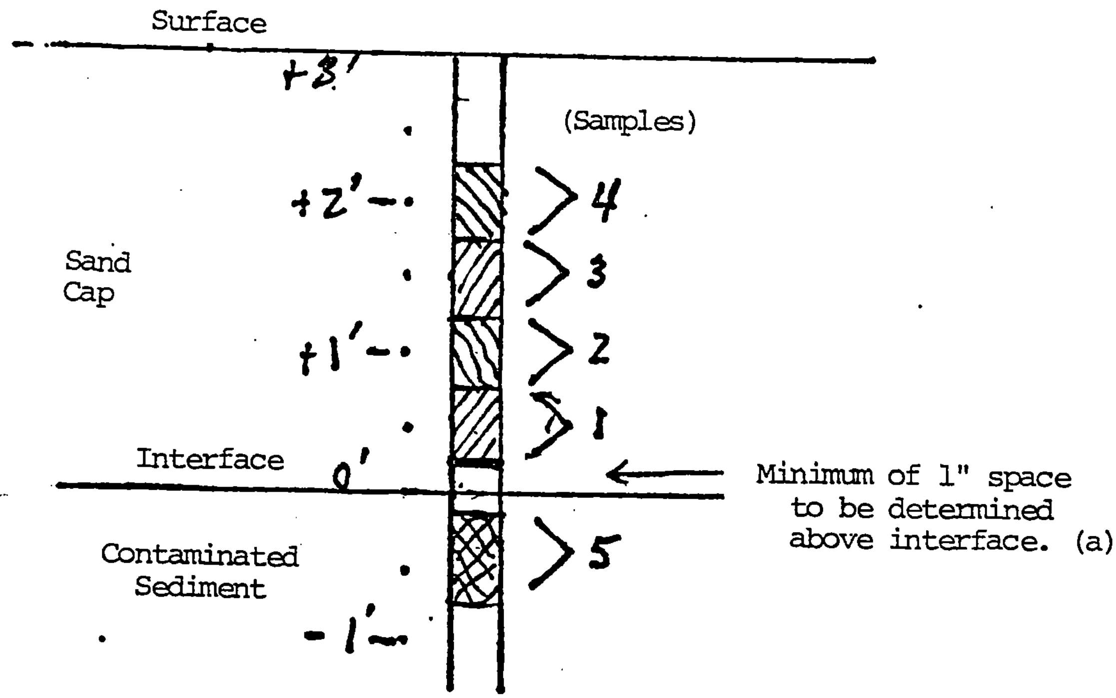


Figure 2. Cross section of sediment core showing the 5 sections that will be taken for chemical analysis.

(a) Determination based on degree of mixing apparent at the interface.

TABLE 2

MONITORING REPORT OUTLINE

Section 1: Background

- Provide information on when and how the sediment cap was placed, including amount of sediment used.

- List permits and licenses obtained and existing permit conditions.

Section 2: Cap placement and thickness

- Provide map showing position and thickness of sediment cap as determined by bathymetric survey and barge dumping records.

- Provide a corrected map of cap thickness based on data from bottom stakes and sediment cores.

- Compare each subsequent survey with the previous survey and discuss whether the cap appears to be remaining stable.

Section 3: Isolation of Contaminants

- Chemical data from baseline cores will be presented in tables and discussed regarding the following:

    - Identify exact sampling locations on cap.
    - Identify presence of chemicals in the existing cap.
    - Compare observed chemistry to pre-dredge data.
    - Check uniformity of chemistry between core sections.
    - Display profile plots of representative chemicals.

- Subsequent core data will be added to the tables to allow comparisons and then discussed regarding the following:.

    - Identify apparent chemical increases in cap.
    - Compare to chemicals in underlying sediments.
    - Display profile plots of representative chemicals.
    - If chemical levels in the cap become significantly elevated, these values will be compared to available Puget Sound Sediment Standards.

Section 4: Surface Contamination of Cap

- Chemistry data from baseline surface grab samples will be presented in tables and discussed regarding the following:

    - Identify exact sampling location on cap.
    - Identify chemicals present on cap surface.
    - Compare chemistry to pre-dredge data and new cores.
    - Identify spatial differences in concentrations.

TABLE 2 (continued)

- Subsequent surface chemistry data will be added to the tables to allow comparisons and discussed regarding the following:

  - Identify chemicals that appear to increase.
  - Display plots of representative chemicals showing change over time.
  - Identify spatial differences and implication to possible sources.
  - If certain chemicals show a trend of significantly increasing concentrations, then potential sources in the collection system will be evaluated for source control actions.
  - If chemical levels in the cap become significantly elevated, the values will be compared to available Puget Sound Sediment Standards.

SECTION 5: Benthic Recolonization

- Detailed taxonomy data will be presented in tables and discussed regarding the following:

  - Identify exact sampling location on cap.
  - Develop summary data regarding number of taxa and biomass.
  - Display plots showing changes over time in numbers of taxa and biomass.
  - Compare the population resulting in the cap after five years to populations found in similar type habitats as determined from previously collected data or a resent sample from an appropriate reference area.

- Video camera survey information will be summarized and discussed relative to the following:

  - Identify location of survey track relative to cap.
  - Assess uniformity of the cap surface.
  - Identify presence of larger biota and shrimp holes

-REMOTS photographs will be presented and discussed regarding the following:

  - Identify location of sample stations on cap.
  - Assess uniformity of capping material across site.
  - Determine infaunal successional stage.
  - Determine organism-sediment index.
  - Quantify linear density of abundant biota.
  - Identify any Redox Potential Discontinuity.
  - Assess indications of bioturbation.

TABLE 2 (continued)

- A comparison of the Video Camera Survey and the REMOTS survey data will be conducted and a recommendation made regarding the preferred approach for obtaining supplemental biological information.

SECTION 6: Conclusions

- Regarding stability of cap
- Regarding isolation of contaminants
- Regarding contamination of cap surface
- Regarding status of benthic recolonization
- Regarding findings of video camera and REMOTS survey
- Regarding recommendations for future actions

APPENDIX B

PRE-CAP DATA

1988 Intertidal Stations

Locator:	Station 33 LTBD19				Station 34 LTBD20				Station 36 LTBD22			
Sampled:	Jun 29, 88				Jun 29, 88				Jun 29, 88			
Lab ID:	8807391				8807392				8807394			
Matrix:	SALTWTRSED				SALTWTRSED				SALTWTRSED			
% Solids:	82				78				80			
Parameters Dry Weight ORGANICS µg/Kg	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
1,2,4-Trichlorobenzene		<MDL	10	21		<MDL	10	22		<MDL	10	21
1,2-Dichlorobenzene		<MDL	10	21		<MDL	10	22		<MDL	10	21
1,2-Diphenylhydrazine		<MDL	40	82		<MDL	40	86		<MDL	40	84
1,3-Dichlorobenzene		<MDL	10	21		<MDL	10	22		<MDL	10	21
1,4-Dichlorobenzene		<MDL	10	21	100		10	22		<MDL	10	21
2,4,5-Trichlorophenol		<MDL	90	160		<MDL	90	170		<MDL	90	160
2,4,6-Trichlorophenol		<MDL	90	160		<MDL	90	170		<MDL	90	160
2,4-Dichlorophenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
2,4-Dimethylphenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
2,4-Dinitrophenol		<MDL	40	82		<MDL	40	86		<MDL	40	84
2,4-Dinitrotoluene		<MDL	9	16		<MDL	9	17		<MDL	9	16
2,6-Dinitrotoluene		<MDL	9	16		<MDL	9	17		<MDL	9	16
2-Chloronaphthalene		<MDL	10	21		<MDL	10	22		<MDL	10	21
2-Chlorophenol		<MDL	40	82		<MDL	40	86		<MDL	40	84
2-Methylnaphthalene		<MDL	40	61		<MDL	40	64		<MDL	40	63
2-Methylphenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
2-Nitroaniline		<MDL				<MDL				<MDL		
2-Nitrophenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
3,3'-Dichlorobenzidine												
3-Nitroaniline		<MDL				<MDL				<MDL		
4,6-Dinitro-O-Cresol		<MDL	40	82		<MDL	40	86		<MDL	40	84
4-Bromophenyl Phenyl Ether		<MDL	6	12		<MDL	6	13		<MDL	6	13
4-Chloro-3-Methylphenol		<MDL	40	82		<MDL	40	86		<MDL	40	84
4-Chloroaniline		<MDL	40	82		<MDL	40	86		<MDL	40	84
4-Chlorophenyl Phenyl Ether		<MDL	10	21		<MDL	10	22		<MDL	10	21
4-Methylphenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
4-Nitroaniline		<MDL				<MDL				<MDL		
4-Nitrophenol		<MDL	40	82		<MDL	40	86		<MDL	40	84
Acenaphthene	61		9	16	190		9	17	190		9	16
Acenaphthylene		<MDL	10	21	35		10	22		<MDL	10	21
Aniline		<MDL	40	82		<MDL	40	86		<MDL	40	84
Anthracene	94		10	21	290		10	22	230		10	21
Benzidine												
Benzo(a)anthracene	260		10	21	860		10	22	340		10	21
Benzo(a)pyrene	230		20	40	680		30	42	240		30	41
Benzo(b)fluoranthene	200		40	61	600		40	64	210		40	63
Benzo(g,h,i)perylene	85		20	40	270		30	42	100		30	41
Benzo(k)fluoranthene	200		40	61	600		40	64	210		40	63
Benzoic Acid	150		60	120	150		60	130	150		60	130
Benzyl Alcohol		<MDL	40	82		<MDL	40	86		<MDL	40	84
Benzyl Butyl Phthalate		<MDL	10	21	550		10	22	250		10	21
Bis(2-Chloroethoxy)Methane		<MDL	20	40		<MDL	30	42		<MDL	30	41
Bis(2-Chloroethyl)Ether		<MDL	20	40		<MDL	30	42		<MDL	30	41
Bis(2-Chloroisopropyl)Ether		<MDL	40	82		<MDL	40	86		<MDL	40	84
Bis(2-Ethylhexyl)Phthalate		<MDL	10	21		<MDL	10	22		<MDL	10	21
Chrysene	320		10	21	990		10	22	500		10	21
Di-N-Butyl Phthalate		<MDL	20	40		<MDL	30	42		<MDL	30	41
Di-N-Octyl Phthalate		<MDL	10	21		<MDL	10	22		<MDL	10	21
Dibenzo(a,h)anthracene		<MDL	40	61	120		40	64		<MDL	40	63
Dibenzofuran	40		20	40	130		30	42	120		30	41
Diethyl Phthalate		<MDL	20	40		<MDL	30	42		<MDL	30	41
Dimethyl Phthalate		<MDL	6	12		<MDL	6	13		<MDL	6	13
Fluoranthene	1100		10	24	2900		10	26	1800		10	25
Fluorene	70		10	21	220		10	22	200		10	21
Hexachlorobenzene		<MDL	10	21		<MDL	10	22		<MDL	10	21

1988 Intertidal Stations (continued)

Locator:	Station 33 LTBD19				Station 34 LTBD20				Station 36 LTBD22			
Sampled:	Jun 29, 88				Jun 29, 88				Jun 29, 88			
Lab ID:	8807391				8807392				8807394			
Matrix:	SALTWTRSED				SALTWTRSED				SALTWTRSED			
% Solids:	82				78				80			
Parameters Dry Weight	**Value**	**Qual**	**MDL**	**RDL**	**Value**	**Qual**	**MDL**	**RDL**	**Value**	**Qual**	**MDL**	**RDL**
Hexachlorobutadiene		<MDL	20	40		<MDL	30	42		<MDL	30	41
Hexachlorocyclopentadiene		<MDL	20	40		<MDL	30	42		<MDL	30	41
Hexachloroethane		<MDL	20	40		<MDL	30	42		<MDL	30	41
Indeno(1,2,3-Cd)Pyrene	89		20	40	280		30	42	100		30	41
Isophorone		<MDL	20	40		<MDL	30	42		<MDL	30	41
N-Nitrosodi-N-Propylamine		<MDL	20	40		<MDL	30	42		<MDL	30	41
N-Nitrosodimethylamine												
N-Nitrosodiphenylamine		<MDL	20	40		<MDL	30	42		<MDL	30	41
Naphthalene		<MDL	40	61		<MDL	40	64		<MDL	40	63
Nitrobenzene		<MDL	20	40		<MDL	30	42		<MDL	30	41
Pentachlorophenol		<MDL	20	40		<MDL	30	42		<MDL	30	41
Phenanthrene	650		10	21	1900		10	22	1400		10	21
Phenol		<MDL	60	120		<MDL	60	130		<MDL	60	130
Pyrene	520		10	21	1700		10	22	840		10	21
4,4'-DDD		<MDL	10	20		<MDL	10	21		<MDL	10	20
4,4'-DDE		<MDL	10	20		<MDL	10	21		<MDL	10	20
4,4'-DDT		<MDL	10	20		<MDL	10	21		<MDL	10	20
Aldrin		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Alpha-BHC		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Aroclor 1016		<MDL	50	98		<MDL	50	100		<MDL	50	100
Aroclor 1221		<MDL	50	98		<MDL	50	100		<MDL	50	100
Aroclor 1232		<MDL	50	98		<MDL	50	100		<MDL	50	100
Aroclor 1242		<MDL	50	98		<MDL	50	100		<MDL	50	100
Aroclor 1248		<MDL	50	98		<MDL	50	100		<MDL	50	100
Aroclor 1254		<MDL	100	200	240		100	210	850		100	200
Aroclor 1260		<MDL	100	200		<MDL	100	210		<MDL	100	200
Beta-BHC		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Chlordane		<MDL	50	98		<MDL	50	100		<MDL	50	100
Delta-BHC		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Dieldrin		<MDL	10	20		<MDL	10	21		<MDL	10	20
Endosulfan I		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Endosulfan II		<MDL	10	20		<MDL	10	21		<MDL	10	20
Endosulfan Sulfate		<MDL	10	20		<MDL	10	21		<MDL	10	20
Endrin		<MDL	10	20		<MDL	10	21		<MDL	10	20
Endrin Aldehyde		<MDL	10	20		<MDL	10	21		<MDL	10	20
Gamma-BHC (Lindane)		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Heptachlor		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Heptachlor Epoxide		<MDL	5	9.8		<MDL	5	10		<MDL	5	10
Methoxychlor		<MDL	50	98		<MDL	50	100		<MDL	50	100
Toxaphene		<MDL	100	200		<MDL	100	210		<MDL	100	200

1988 Intertidal Stations (continued)

Locator:	Station 33 LTBD19				Station 34 LTBD20				Station 36 LTBD22			
Sampled:	Jun 29, 88				Jun 29, 88				Jun 29, 88			
Lab ID:	8807391				8807392				8807394			
Matrix:	SALTWTRSED				SALTWTRSED				SALTWTRSED			
% Solids:	82				78				80			
Parameters Dry Weight	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
METALS Dry Weight mg/Kg												
M.Code=CV												
Mercury	0.55	E			1.3	E			0.54	E		
M.Code=GF												
Antimony	0.49	E			2.2	E			1.4	E		
Thallium	0.085	E				<MDL,E	0.06			<MDL,E	0.06	
M.Code=HE												
Arsenic	8.7	E			5.3	E			16	E		
Selenium		<MDL,E	0.06			<MDL,E	0.06			<MDL,E	0.06	
M.Code=PE												
Aluminum	7800	E			9100	E			7000	E		
Barium	22	E			74	E			24	E		
Beryllium	0.24	E			0.26	E			0.13	E		
Cadmium	1.6	E,L			2.6	E,L			1.4	E,L		
Chromium	27	E			53	E			36	E		
Copper	400	E,B			240	E,B			160	E,B		
Iron	13000	E			15000	E			11000	E		
Lead	290	E			210	E			300	E		
Manganese	180				190				160			
Nickel	35	E			46	E			30	E		
Silver	6.6	E			12	E			6.5	E		
Zinc	180	E,L			260	E,L			250	E,L		
CONVENTIONALS												
Particle Size in %												
p-2.00		<MDL,E	0.01		0.63	E	0.01		42	E	0.01	
p-1.00	0.22	E	0.01		1.4	E	0.01		8.6	E	0.01	
p+0.00	7.3	E	0.01		19	E	0.01		5.2	E	0.01	
p+1.00	27	E	0.01		24	E	0.01		7.3	E	0.01	
p+2.00	52	E	0.01		26	E	0.01		27	E	0.01	
p+3.00	12	E	0.01		22	E	0.01		9.5	E	0.01	
p+4.00	0.22	E	0.01		3.2	E	0.01		0.3	E	0.01	
p+5.00	2.1	E	0.01		2.9	E	0.01		0.1	E	0.01	
p+6.00												
p+7.00												
p+8.00												
p+9.00												
p+10.0												
p+11.0												
p+12.0												
Total Organic Carbon mg/Kg												
FIELD DATA												
Storm Or Non-Storm	N				N				N			
Tidal Condition	E				E				E			
M.Code=(No Method Code)												
Sample Function	SAMP				SAMP				SAMP			
Sample Start Time	1030				1115				1100			
Sediment Sampling Range Bottc	5				5				5			
Sediment Sampling Range Top	0				0				0			

Duwamish River Sediment Samples

Composite/Locator: Sampled: Lab ID: Matrix: % Solids: Parameters Dry Weight ORGANICS µg/Kg	1 LTXP06 Apr 20, 89 8905264 SALTWTRSED 87 Value	 Qual	 MDL	 RDL	2 LTXP06 Apr 20, 89 8905265 SALTWTRSED 74 Value	 Qual	 MDL	 RDL
1,2,4-Trichlorobenzene		<MDL	2	4.7		<MDL	3	5.7
1,2-Dichlorobenzene		<MDL	2	4.7		<MDL	3	5.7
1,2-Diphenylhydrazine		<MDL	9	18		<MDL	10	23
1,3-Dichlorobenzene		<MDL	2	4.7		<MDL	3	5.7
1,4-Dichlorobenzene		<MDL	2	4.7		<MDL	3	5.7
2,4,5-Trichlorophenol		<MDL	20	38		<MDL	30	45
2,4,6-Trichlorophenol		<MDL	20	38		<MDL	30	45
2,4-Dichlorophenol		<MDL	5	9.4		<MDL	5	11
2,4-Dimethylphenol		<MDL	5	9.4		<MDL	5	11
2,4-Dinitrophenol		<MDL	9	18		<MDL	10	23
2,4-Dinitrotoluene		<MDL	2	3.8		<MDL	3	4.5
2,6-Dinitrotoluene		<MDL	2	3.8		<MDL	3	4.5
2-Chloronaphthalene		<MDL	2	4.7		<MDL	3	5.7
2-Chlorophenol		<MDL	9	18		<MDL	10	23
2-Methylnaphthalene		<MDL	7	14		<MDL	9	18
2-Methylphenol		<MDL	5	9.4		<MDL	5	11
2-Nitroaniline		<MDL	10	29		<MDL	10	34
2-Nitrophenol		<MDL	5	9.4		<MDL	5	11
3,3'-Dichlorobenzidine								
3-Nitroaniline		<MDL	10	29		<MDL	10	34
4,6-Dinitro-O-Cresol		<MDL	9	18		<MDL	10	23
4-Bromophenyl Phenyl Ether		<MDL	1	2.9		<MDL	1	3.4
4-Chloro-3-Methylphenol		<MDL	9	18		<MDL	10	23
4-Chloroaniline		<MDL	9	18		<MDL	10	23
4-Chlorophenyl Phenyl Ether		<MDL	2	4.7		<MDL	3	5.7
4-Methylphenol		<MDL	5	9.4		<MDL	5	11
4-Nitroaniline		<MDL	10	29		<MDL	10	34
4-Nitrophenol		<MDL	9	18		<MDL	10	23
Acenaphthene		<MDL	2	3.8		<MDL	3	4.5
Acenaphthylene		<MDL	2	4.7		<MDL	3	5.7
Aniline		<MDL	9	18		<MDL	10	23
Anthracene		<MDL	2	4.7		<MDL	3	5.7
Benzidine		<MDL	100	230		<MDL	100	270
Benzo(a)anthracene		<MDL	2	4.7	9.6		3	5.7
Benzo(a)pyrene		<MDL	5	9.4		<MDL	5	11
Benzo(b)fluoranthene		<MDL	7	14		<MDL	9	18
Benzo(g,h,i)perylene		<MDL	5	9.4		<MDL	5	11
Benzo(k)fluoranthene		<MDL	7	14		<MDL	9	18
Benzoic Acid		<MDL	10	29		<MDL	10	34
Benzyl Alcohol		<MDL	9	18		<MDL	10	23
Benzyl Butyl Phthalate		<MDL	2	4.7		<MDL	3	5.7
Bis(2-Chloroethoxy)Methane		<MDL	5	9.4		<MDL	5	11
Bis(2-Chloroethyl)Ether		<MDL	5	9.4		<MDL	5	11
Bis(2-Chloroisopropyl)Ether		<MDL	9	18		<MDL	10	23
Bis(2-Ethylhexyl)Phthalate		<MDL	2	4.7		<MDL	3	5.7
Chrysene		<MDL	2	4.7	15		3	5.7
Di-N-Butyl Phthalate		<MDL	5	9.4		<MDL	5	11
Di-N-Octyl Phthalate		<MDL	2	4.7		<MDL	3	5.7
Dibenzo(a,h)anthracene		<MDL	7	14		<MDL	9	18
Dibenzofuran		<MDL	5	9.4		<MDL	5	11
Diethyl Phthalate		<MDL	5	9.4		<MDL	5	11
Dimethyl Phthalate		<MDL	1	2.9		<MDL	1	3.4
Fluoranthene	5.7		2	5.6	26		4	6.8
Fluorene		<MDL	2	4.7		<MDL	3	5.7
Hexachlorobenzene		<MDL	2	4.7		<MDL	3	5.7

Duwamish River Sediment Samples (continued)

Composite/Locator:		1 LTXP06				2 LTXP06		
Sampled:		Apr 20, 89				Apr 20, 89		
Lab ID:		8905264				8905265		
Matrix:		SALTWTRSED				SALTWTRSED		
% Solids:		87				74		
Parameters Dry Weight	**Value**	**Qual**	**MDL**	**RDL**	**Value**	**Qual**	**MDL**	**RDL**
Hexachlorobutadiene		<MDL	5	9.4		<MDL	5	11
Hexachlorocyclopentadiene		<MDL	5	9.4		<MDL	5	11
Hexachloroethane		<MDL	5	9.4		<MDL	5	11
Indeno(1,2,3-Cd)Pyrene		<MDL	5	9.4		<MDL	5	11
Isophorone		<MDL	5	9.4		<MDL	5	11
N-Nitrosodi-N-Propylamine		<MDL	5	9.4		<MDL	5	11
N-Nitrosodimethylamine		<MDL	10	29		<MDL	10	34
N-Nitrosodiphenylamine		<MDL	5	9.4		<MDL	5	11
Naphthalene		<MDL	7	14		<MDL	9	18
Nitrobenzene		<MDL	5	9.4		<MDL	5	11
Pentachlorophenol		<MDL	5	9.4		<MDL	5	11
Phenanthrene		<MDL	2	4.7	15		3	5.7
Phenol		<MDL	10	29		<MDL	10	34
Pyrene	5.3		2	4.7	30		3	5.7
4,4'-DDD		<MDL	0.5	0.95		<MDL	0.5	1.1
4,4'-DDE		<MDL	0.5	0.95		<MDL	0.5	1.1
4,4'-DDT		<MDL,G	0.5	0.95		<MDL,G	0.5	1.1
Aldrin		<MDL,G	0.5	0.92		<MDL,G	0.5	1.1
Alpha-BHC		<MDL	0.5	0.92		<MDL	0.5	1.1
Aroclor 1016		<MDL	5	9.5		<MDL	6	11
Aroclor 1221		<MDL	5	9.5		<MDL	6	11
Aroclor 1232		<MDL	5	9.5		<MDL	6	11
Aroclor 1242		<MDL	5	9.5		<MDL	6	11
Aroclor 1248		<MDL	5	9.5		<MDL	6	11
Aroclor 1254		<MDL	5	9.5		<MDL	6	11
Aroclor 1260		<MDL	5	9.5		<MDL	6	11
Beta-BHC		<MDL	0.5	0.92		<MDL	0.5	1.1
Chlordane		<MDL	2	4.8		<MDL	3	5.7
Delta-BHC		<MDL	0.5	0.92		<MDL	0.5	1.1
Dieldrin		<MDL,G	0.5	0.95		<MDL,G	0.5	1.1
Endosulfan I		<MDL	0.5	0.92		<MDL	0.5	1.1
Endosulfan II		<MDL	0.5	0.95		<MDL	0.5	1.1
Endosulfan Sulfate		<MDL	0.5	0.95		<MDL	0.5	1.1
Endrin		<MDL	0.5	0.95		<MDL	0.5	1.1
Endrin Aldehyde		<MDL	0.5	0.95		<MDL	0.5	1.1
Gamma-BHC (Lindane)		<MDL,G	0.5	0.92		<MDL,G	0.5	1.1
Heptachlor		<MDL,G	0.5	0.92		<MDL,G	0.5	1.1
Heptachlor Epoxide		<MDL	0.5	0.92		<MDL	0.5	1.1
Methoxychlor		<MDL	2	4.8		<MDL	3	5.7
Toxaphene		<MDL	5	9.5		<MDL	6	11
1,1,1-Trichloroethane		<MDL	1	2.3		<MDL	1	2.7
1,1,2,2-Tetrachloroethane		<MDL	1	2.3		<MDL	1	2.7
1,1,2-Trichloroethane		<MDL	1	2.3		<MDL	1	2.7
1,1,2-Trichloroethylene		<MDL	1	2.3		<MDL	1	2.7
1,1-Dichloroethane		<MDL	1	2.3		<MDL	1	2.7
1,1-Dichloroethylene		<MDL	1	2.3		<MDL	1	2.7
1,2-Dichloroethane		<MDL	1	2.3		<MDL	1	2.7
1,2-Dichloropropane		<MDL	1	2.3		<MDL	1	2.7
2-Butanone (MEK)		<MDL	6	11		<MDL	7	14
2-Chloroethylvinyl ether		<MDL	1	2.3		<MDL	1	2.7
2-Hexanone		<MDL	6	11		<MDL	7	14
4-Methyl-2-Pentanone (MIBK)		<MDL	6	11		<MDL	7	14
Acetone		<MDL	6	11		<MDL	7	14
Acrolein		<MDL	6	11		<MDL	7	14
Acrylonitrile		<MDL	6	11		<MDL	7	14
Benzene		<MDL	1	2.3		<MDL	1	2.7

Duwamish River Sediment Samples (continued)

Composite/Locator:		1 LTXP06				2 LTXP06		
Sampled:		Apr 20, 89				Apr 20, 89		
Lab ID:		8905264				8905265		
Matrix:		SALTWTRSED				SALTWTRSED		
% Solids:		87				74		
Parameters Dry Weight	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
Bromodichloromethane		<MDL	1	2.3		<MDL	1	2.7
Bromoform		<MDL	1	2.3		<MDL	1	2.7
Bromomethane		<MDL	1	2.3		<MDL	1	2.7
Carbon Disulfide		<MDL	1	2.3		<MDL	1	2.7
Carbon Tetrachloride		<MDL	1	2.3		<MDL	1	2.7
Chlorobenzene		<MDL	1	2.3		<MDL	1	2.7
Chlorodibromomethane		<MDL	1	2.3		<MDL	1	2.7
Chloroethane		<MDL	1	2.3		<MDL	1	2.7
Chloroform		<MDL	1	2.3		<MDL	1	2.7
Chloromethane		<MDL	1	2.3		<MDL	1	2.7
cis-1,3-Dichloropropene		<MDL	1	2.3		<MDL	1	2.7
Ethylbenzene		<MDL	1	2.3		<MDL	1	2.7
Methylene Chloride		<MDL	6	11		<MDL	7	14
Styrene		<MDL	1	2.3		<MDL	1	2.7
Tetrachloroethylene		<MDL	1	2.3		<MDL	1	2.7
Toluene		<MDL	1	2.3		<MDL	1	2.7
Total Xylenes		<MDL	1	2.3		<MDL	1	2.7
Trans-1,2-Dichloroethylene		<MDL	1	2.3		<MDL	1	2.7
Trans-1,3-Dichloropropene		<MDL	1	2.3		<MDL	1	2.7
Trichlorofluoromethane		<MDL	1	2.3		<MDL	1	2.7
Vinyl Acetate		<MDL	6	11		<MDL	7	14
Vinyl Chloride		<MDL	1	2.3		<MDL	1	2.7

Duwamish River Sediment Samples (continued)

Composite/Locator:	1 LTXP06				2 LTXP06			
Sampled:	Apr 20, 89				Apr 20, 89			
Lab ID:	8905264				8905265			
Matrix:	SALTWTRSED				SALTWTRSED			
% Solids:	87				74			
Parameters Dry Weight	**Value**	**Qual**	**MDL**	**RDL**	**Value**	**Qual**	**MDL**	**RDL**
METALS mg/Kg								
M.Code=CV								
Mercury		<MDL,E	0.2		0.041	E		
M.Code=GF								
Antimony	0.48	E			0.32	E		
Thallium								
M.Code=HE								
Arsenic	7.8	E			7	E		
Selenium								
M.Code=PE								
Aluminum								
Barium								
Beryllium								
Cadmium	0.069	E			0.14	E		
Chromium								
Copper	13	E			13	E		
Iron	3.8	E			3.5	E		
Lead	5.7	E			9.6	E		
Manganese								
Nickel	28	E			28	E		
Silver	0.34	E			0.39	E		
Zinc	79	E			91	E		
FIELD DATA								
Storm Or Non-Storm								
Tidal Condition								
Sample Function	SAMP				SAMP			
Sample Start Time								
Sediment Sampling Range Bottom	122				364			
Sediment Sampling Range Top	0				123			

Duwamish River Sediment Samples (continued)

Composite/Locator:	3 LTXP07				4 LTXP07			
Sampled:	Apr 20, 89				Apr 20, 89			
Lab ID:	8905266				8905267			
Matrix:	SALTWTRSED				SALTWTRSED			
% Solids:	87				70			
Parameters Dry Weight ORGANICS μg/Kg	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
1,2,4-Trichlorobenzene		<MDL	2	4.8		<MDL	3	6
1,2-Dichlorobenzene		<MDL	2	4.8		<MDL	3	6
1,2-Diphenylhydrazine		<MDL	10	20		<MDL	10	24
1,3-Dichlorobenzene		<MDL	2	4.8		<MDL	3	6
1,4-Dichlorobenzene		<MDL	2	4.8		<MDL	3	6
2,4,5-Trichlorophenol		<MDL	20	38		<MDL	30	47
2,4,6-Trichlorophenol		<MDL	20	38		<MDL	30	47
2,4-Dichlorophenol		<MDL	5	9.5		<MDL	6	12
2,4-Dimethylphenol		<MDL	5	9.5		<MDL	6	12
2,4-Dinitrophenol		<MDL	10	20		<MDL	10	24
2,4-Dinitrotoluene		<MDL	2	3.8		<MDL	3	4.7
2,6-Dinitrotoluene		<MDL	2	3.8		<MDL	3	4.7
2-Chloronaphthalene		<MDL	2	4.8		<MDL	3	6
2-Chlorophenol		<MDL	10	20		<MDL	10	24
2-Methylnaphthalene		<MDL	8	15		<MDL	10	19
2-Methylphenol		<MDL	5	9.5		<MDL	6	12
2-Nitroaniline		<MDL	10	29		<MDL	10	36
2-Nitrophenol		<MDL	5	9.5		<MDL	6	12
3,3'-Dichlorobenzidine								
3-Nitroaniline		<MDL	10	29		<MDL	10	36
4,6-Dinitro-O-Cresol		<MDL	10	20		<MDL	10	24
4-Bromophenyl Phenyl Ether		<MDL	1	2.9		<MDL	1	3.6
4-Chloro-3-Methylphenol		<MDL	10	20		<MDL	10	24
4-Chloroaniline		<MDL	10	20		<MDL	10	24
4-Chlorophenyl Phenyl Ether		<MDL	2	4.8		<MDL	3	6
4-Methylphenol		<MDL	5	9.5	37		6	12
4-Nitroaniline		<MDL	10	29		<MDL	10	36
4-Nitrophenol		<MDL	10	20		<MDL	10	24
Acenaphthene		<MDL	2	3.8	5.1		3	4.7
Acenaphthylene		<MDL	2	4.8		<MDL	3	6
Aniline		<MDL	10	20		<MDL	10	24
Anthracene		<MDL	2	4.8	11		3	6
Benzidine		<MDL	100	230		<MDL	100	290
Benzo(a)anthracene		<MDL	2	4.8	29		3	6
Benzo(a)pyrene		<MDL	5	9.5	34		6	12
Benzo(b)fluoranthene		<MDL	8	15	39		10	19
Benzo(g,h,i)perylene		<MDL	5	9.5		<MDL	6	12
Benzo(k)fluoranthene		<MDL	8	15	43		10	19
Benzoic Acid		<MDL	10	29	60		10	36
Benzyl Alcohol		<MDL	10	20		<MDL	10	24
Benzyl Butyl Phthalate		<MDL	2	4.8		<MDL	3	6
Bis(2-Chloroethoxy)Methane		<MDL	5	9.5		<MDL	6	12
Bis(2-Chloroethyl)Ether		<MDL	5	9.5		<MDL	6	12
Bis(2-Chloroisopropyl)Ether		<MDL	10	20		<MDL	10	24
Bis(2-Ethylhexyl)Phthalate		<MDL	2	4.8		<MDL	3	6
Chrysene	5.3		2	4.8	46		3	6
Di-N-Butyl Phthalate		<MDL	5	9.5		<MDL	6	12
Di-N-Octyl Phthalate		<MDL	2	4.8		<MDL	3	6
Dibenzo(a,h)anthracene		<MDL	8	15		<MDL	10	19
Dibenzofuran		<MDL	5	9.5		<MDL	6	12
Diethyl Phthalate		<MDL	5	9.5		<MDL	6	12
Dimethyl Phthalate		<MDL	1	2.9		<MDL	1	3.6
Fluoranthene	11		3	5.7	69		4	7.1
Fluorene		<MDL	2	4.8	6		3	6
Hexachlorobenzene		<MDL	2	4.8		<MDL	3	6

Duwamish River Sediment Samples (continued)

Composite/Locator:	3 LTXP07				4 LTXP07			
Sampled:	Apr 20, 89				Apr 20, 89			
Lab ID:	8905266				8905267			
Matrix:	SALTWTRSED				SALTWTRSED			
% Solids:	87				70			
Parameters Dry Weight	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
Hexachlorobutadiene		<MDL	5	9.5		<MDL	6	12
Hexachlorocyclopentadiene		<MDL	5	9.5		<MDL	6	12
Hexachloroethane		<MDL	5	9.5		<MDL	6	12
Indeno(1,2,3-Cd)Pyrene		<MDL	5	9.5		<MDL	6	12
Isophorone		<MDL	5	9.5		<MDL	6	12
N-Nitrosodi-N-Propylamine		<MDL	5	9.5		<MDL	6	12
N-Nitrosodimethylamine		<MDL	10	29		<MDL	10	36
N-Nitrosodiphenylamine		<MDL	5	9.5		<MDL	6	12
Naphthalene		<MDL	8	15		<MDL	10	19
Nitrobenzene		<MDL	5	9.5		<MDL	6	12
Pentachlorophenol		<MDL	5	9.5		<MDL	6	12
Phenanthrene	8.6		2	4.8	56		3	6
Phenol		<MDL	10	29		<MDL	10	36
Pyrene	14		2	4.8	89		3	6
4,4'-DDD		<MDL	0.5	0.95		<MDL	0.6	1.2
4,4'-DDE		<MDL	0.5	0.95		<MDL	0.6	1.2
4,4'-DDT		<MDL,G	0.5	0.95		<MDL,G	0.6	1.2
Aldrin		<MDL,G	0.5	0.92		<MDL,G	0.6	1.1
Alpha-BHC		<MDL	0.5	0.92		<MDL	0.6	1.1
Aroclor 1016		<MDL	5	9.5		<MDL	6	12
Aroclor 1221		<MDL	5	9.5		<MDL	6	12
Aroclor 1232		<MDL	5	9.5		<MDL	6	12
Aroclor 1242		<MDL	5	9.5		<MDL	6	12
Aroclor 1248		<MDL	5	9.5		<MDL	6	12
Aroclor 1254		<MDL	5	9.5		<MDL	6	12
Aroclor 1260		<MDL	5	9.5		<MDL	6	12
Beta-BHC		<MDL	0.5	0.92		<MDL	0.6	1.1
Chlordane		<MDL	2	4.8		<MDL	3	6
Delta-BHC		<MDL	0.5	0.92		<MDL	0.6	1.1
Dieldrin		<MDL,G	0.5	0.95		<MDL,G	0.6	1.2
Endosulfan I		<MDL	0.5	0.92		<MDL	0.6	1.1
Endosulfan II		<MDL	0.5	0.95		<MDL	0.6	1.2
Endosulfan Sulfate		<MDL	0.5	0.95		<MDL	0.6	1.2
Endrin		<MDL	0.5	0.95		<MDL	0.6	1.2
Endrin Aldehyde		<MDL	0.5	0.95		<MDL	0.6	1.2
Gamma-BHC (Lindane)		<MDL,G	0.5	0.92		<MDL,G	0.6	1.1
Heptachlor		<MDL,G	0.5	0.92		<MDL,G	0.6	1.1
Heptachlor Epoxide		<MDL	0.5	0.92		<MDL	0.6	1.1
Methoxychlor		<MDL	2	4.8		<MDL	3	6
Toxaphene		<MDL	5	9.5		<MDL	6	12
1,1,1-Trichloroethane		<MDL	1	2.3		<MDL	1	2.9
1,1,2,2-Tetrachloroethane		<MDL	1	2.3		<MDL	1	2.9
1,1,2-Trichloroethane		<MDL	1	2.3		<MDL	1	2.9
1,1,2-Trichloroethylene		<MDL	1	2.3		<MDL	1	2.9
1,1-Dichloroethane		<MDL	1	2.3		<MDL	1	2.9
1,1-Dichloroethylene		<MDL	1	2.3		<MDL	1	2.9
1,2-Dichloroethane		<MDL	1	2.3		<MDL	1	2.9
1,2-Dichloropropane		<MDL	1	2.3		<MDL	1	2.9
2-Butanone (MEK)		<MDL	6	11	39		7	14
2-Chloroethylvinyl ether		<MDL	1	2.3		<MDL	1	2.9
2-Hexanone		<MDL	6	11		<MDL	7	14
4-Methyl-2-Pentanone (MIBK)		<MDL	6	11		<MDL	7	14
Acetone		<MDL	6	11	91		7	14
Acrolein		<MDL	6	11		<MDL	7	14
Acrylonitrile		<MDL	6	11		<MDL	7	14
Benzene		<MDL	1	2.3		<MDL	1	2.9

Duwamish River Sediment Samples (continued)

Composite/Locator:	3 LTXP07				4 LTXP07			
Sampled:	Apr 20, 89				Apr 20, 89			
Lab ID:	8905266				8905267			
Matrix:	SALTWTRSED				SALTWTRSED			
% Solids:	87				70			
Parameters Dry Weight	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
Bromodichloromethane		<MDL	1	2.3		<MDL	1	2.9
Bromoform		<MDL	1	2.3		<MDL	1	2.9
Bromomethane		<MDL	1	2.3		<MDL	1	2.9
Carbon Disulfide		<MDL	1	2.3		<MDL	1	2.9
Carbon Tetrachloride		<MDL	1	2.3		<MDL	1	2.9
Chlorobenzene		<MDL	1	2.3		<MDL	1	2.9
Chlorodibromomethane		<MDL	1	2.3		<MDL	1	2.9
Chloroethane		<MDL	1	2.3		<MDL	1	2.9
Chloroform		<MDL	1	2.3		<MDL	1	2.9
Chloromethane		<MDL	1	2.3		<MDL	1	2.9
cis-1,3-Dichloropropene		<MDL	1	2.3		<MDL	1	2.9
Ethylbenzene		<MDL	1	2.3		<MDL	1	2.9
Methylene Chloride		<MDL	6	11		<MDL	7	14
Styrene		<MDL	1	2.3		<MDL	1	2.9
Tetrachloroethylene		<MDL	1	2.3		<MDL	1	2.9
Toluene		<MDL	1	2.3		<MDL	1	2.9
Total Xylenes		<MDL	1	2.3		<MDL	1	2.9
Trans-1,2-Dichloroethylene		<MDL	1	2.3		<MDL	1	2.9
Trans-1,3-Dichloropropene		<MDL	1	2.3		<MDL	1	2.9
Trichlorofluoromethane		<MDL	1	2.3		<MDL	1	2.9
Vinyl Acetate		<MDL	6	11		<MDL	7	14
Vinyl Chloride		<MDL	1	2.3		<MDL	1	2.9

Duwamish River Sediment Samples (continued)

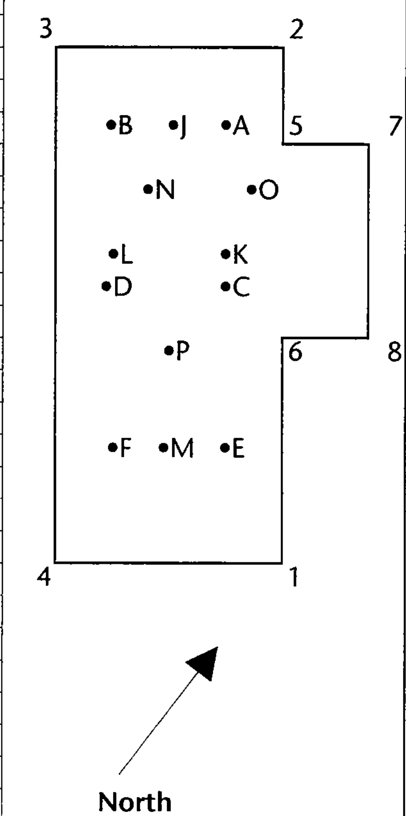
Composite/Locator:	3 LTXP07				4 LTXP07			
Sampled:	Apr 20, 89				Apr 20, 89			
Lab ID:	8905266				8905267			
Matrix:	SALTWTRSED				SALTWTRSED			
% Solids:	87				70			
Parameters Dry Weight	Value	Qual	MDL	RDL	Value	Qual	MDL	RDL
METALS mg/Kg								
M.Code=CV								
Mercury	0.023	E			0.043	E		
M.Code=GF								
Antimony	0.48	E			0.57	E		
Thallium								
M.Code=HE								
Arsenic	5.9	E			7.7	E		
Selenium								
M.Code=PE								
Aluminum								
Barium								
Beryllium								
Cadmium	0.057	E			0.23	E		
Chromium								
Copper	14	E			27	E		
Iron	3.2	E			3.6	E		
Lead	7.6	E			19	E		
Manganese								
Nickel	26	E			31	E		
Silver	0.33	E			0.3	E		
Zinc	79	E			100	E		
FIELD DATA								
Storm Or Non-Storm								
Tidal Condition								
Sample Function	SAMP				SAMP			
Sample Start Time								
Sediment Sampling Range Bottom	122				364			
Sediment Sampling Range Top	0				123			

APPENDIX C

COORDINATE LOCATIONS

Cap, Stake, and Station Coordinates, NAD 27

Corner	Northing	Easting
1	229	1623.73
2	229.44	1623.33
3	229.31	1623.18
4	228.87	1623.58
5	229.32	1623.44
6	229.2	1623.55
7	229.36	1623.5
8	229.25	1623.6
Stake		
A	229.37	1623.34
B	229.3	1623.26
C	229.19	1623.5
D	229.12	1623.42
E	229.01	1623.66
F	228.94	1623.58
Station		
J	229.3	1623.33
K	229.238	1623.441
L	229.157	1623.395
M	229.02	1623.57
N	229.25	1623.38
O	229.3	1623.46
P	229.09	1623.528



APPENDIX D

SEDIMENT-PROFILE CAMERA SURVEY

REMOTS® SURVEY OF THE DENNY WAY CSO CAP
ELLIOTT BAY, WA, OCTOBER 1991

Final Report

17 March 1992

SAIC Project No. 01-0098-05-0687
Report # 9203.016/0687/B.011
Purchase Order No. R35384

Submitted to:

Municipality of Metropolitan Seattle
Exchange Building
821 Second Avenue
Seattle, Washington 98014-1598

Submitted by:

Science Applications International Corporation
Ocean Science and Technology Division
18706 North Creek Parkway, Suite 110
Bothell, WA 98011

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1.0 INTRODUCTION

On 23 October 1991, Science Applications International Corporation (SAIC) of Bothell, WA conducted a REMOTS® sediment-profile imaging survey for the Municipality of Metropolitan Seattle (METRO). This survey was performed at the sediment capping area at the Denny Way combined sewage overflow (CSO). This survey was performed under contract through METRO purchase order R35384.

The Denny Way CSO is located within a small embayment on the northeastern shore of Elliott Bay at the foot of Denny Way, approximately 850 feet northwest of the tip of Pier 71. The sediment capping area is offshore of the CSO in water depths ranging from 20 to 60 feet Mean Low Lower Water (MLLW). The capped area measures approximately 200 feet by 600 feet and is rectangular in shape. The location of the Denny Way Cap is presented in Figure 1-1.

The Denny Way Cap overlies native sediments (32-58% sand, 37-59% silt, 4-10% clay) which had been identified as a potential toxic problem area in the Elliott Bay Action Program (Tetra Tech, 1986). The sand cap was emplaced from 16 to 30 March 1990 and consisted of thirteen bargeloads of clean sand from the Duwamish waterway. The total volume of sands emplaced as capping material was 20,000 cubic yards. The sands used for the cap were tested prior to emplacement and found to be free of chemical contaminants. The function of the cap is to isolate any toxic contaminants within the buried native sediments from marine biota.

The sediment profile survey was one element of the post-emplacement cap monitoring plan. Two primary questions addressed by the sediment profile monitoring were,

- what are the present biological conditions on the cap, and
- what is the areal extent of capping sand?

In addition to those objectives, the sediment profile survey provided information describing the physical condition of the cap and the results of the REMOTS® survey were also correlated with benthic infaunal data, biomass data, and videotapes acquired during separate surveys of the cap area.

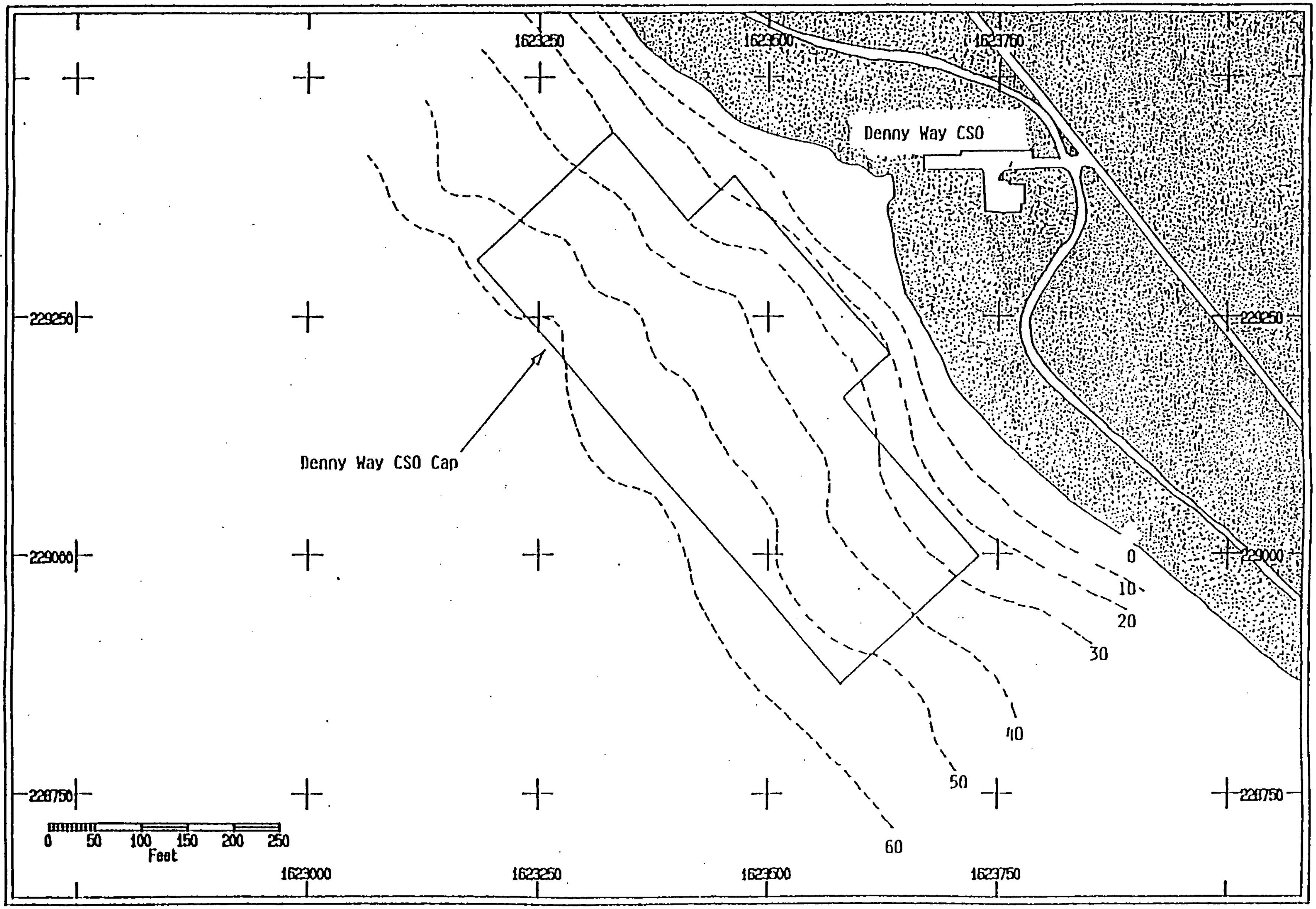

Figure 1-1. The location of the Denny Way CSO and the sediment capping area (rectangular solid). Water depths are in feet (MLLW).

2.0 METHODS

2.1 Field Collections

To conduct the sediment profile survey, mobilization of METRO's research vessel, the R.V. LIBERTY, commenced on 22 October 1991. The sediment profile survey was conducted on 23 October 1991 from 0700 to 1830 hours. Final demobilization occurred on 23 October, immediately following the completion of field operations.

The sediment cap was surveyed using a sampling design consisting of three cross-slope and two along-slope transects. This sampling design was formulated in consultation with METRO. Prior to the sediment profile survey, diver held video camera and other monitoring surveys were conducted at the capping area. During these previous surveys, a series of six stakes were set within the bottom at the capping area to identify monitoring stations. The locations of these stakes and their positions relative to the cap boundary are shown in Figure 2-1. Each of the three across slope transects of the sediment profile survey were defined by two stakes, A and B, C and D, and E and F respectively. In addition, each across slope transect consisted of seven stations spaced at 50 foot intervals. The transects started at the shoreward edge of the cap boundary and extended seaward. The transect defined by stakes D and C contained eight stations as the cap boundary projects shoreward in the vicinity of the Denny Way CSO. The station nomenclature consists of the transect followed by the station number along the transect. Station numbers increase with distance away from the shoreward edge of the cap boundary. Replicate images from the same station share the same alphanumeric station names and are followed by an A, B or C.

The two along slope transects occupied during the sediment profile survey are also defined by stake locations. These transects are called ECA and FDB. Station numbering is similar to that of the cross-slope transects described above with the exception that the along slope stations were not consistently spaced at 50 meter intervals. The target sampling grid is presented in Figure 2-2.

During the REMOTS® survey conducted on 23 October 1991, a total of 106 sediment profile images were collected from 38 stations within and adjacent to the cap boundary. Three replicate images were obtained from 26 of the 38 stations while four replicate images were collected from two stations and two replicate images were collected at each of the remaining stations. At each of the cross-slope transect stations, three replicate images were collected. A total of 24 images, one replicate from each of 24 stations, were selected for image analysis for selected REMOTS® parameters. The REMOTS® images which were analyzed were

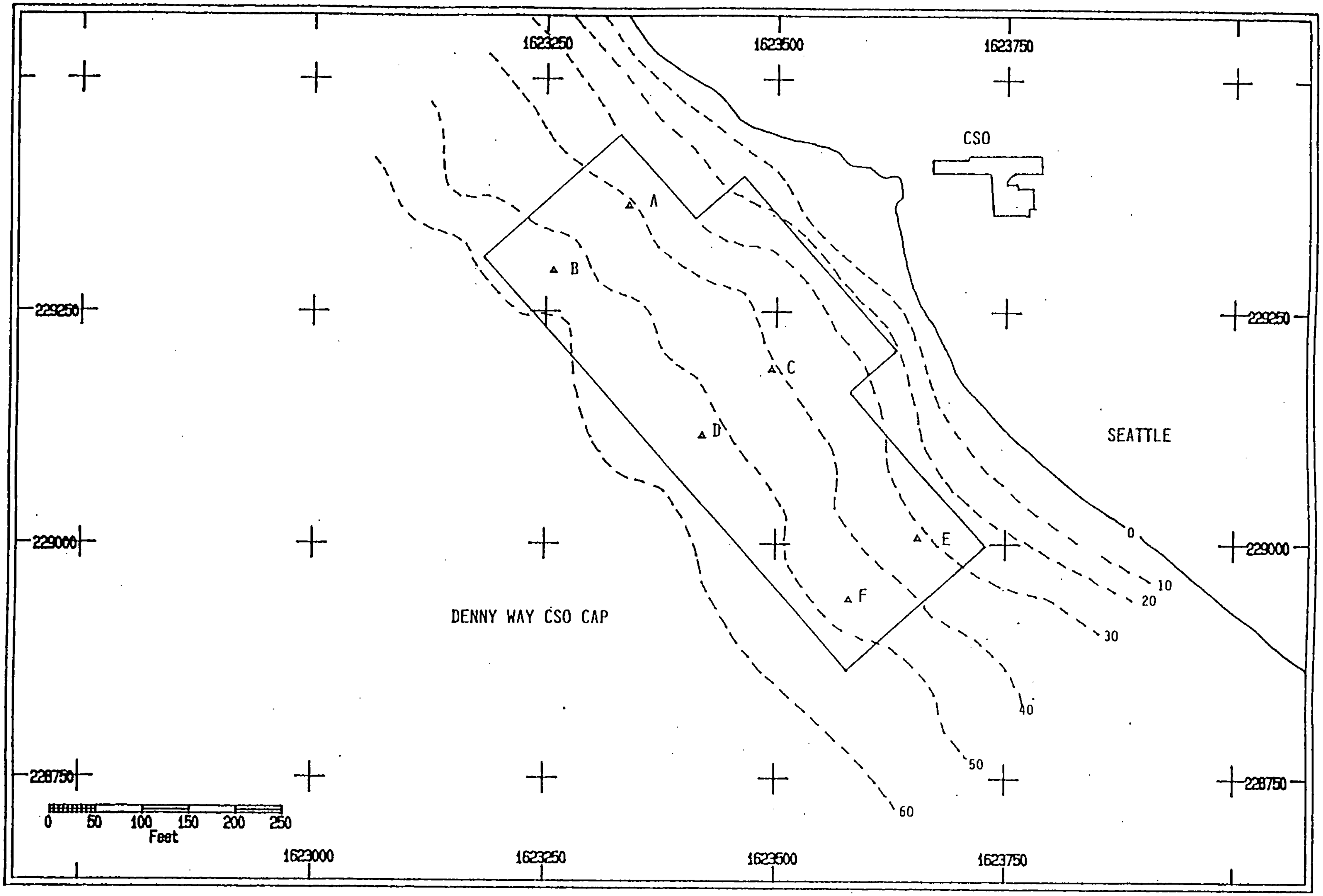

Figure 2-1. The location of stakes defining sampling transects occupied during the October 1991 Denny Way CSO cap survey. These stakes were established by METRO for field collections prior to the October 1991 REMOTS® survey. Water depths are in feet (MLLW).

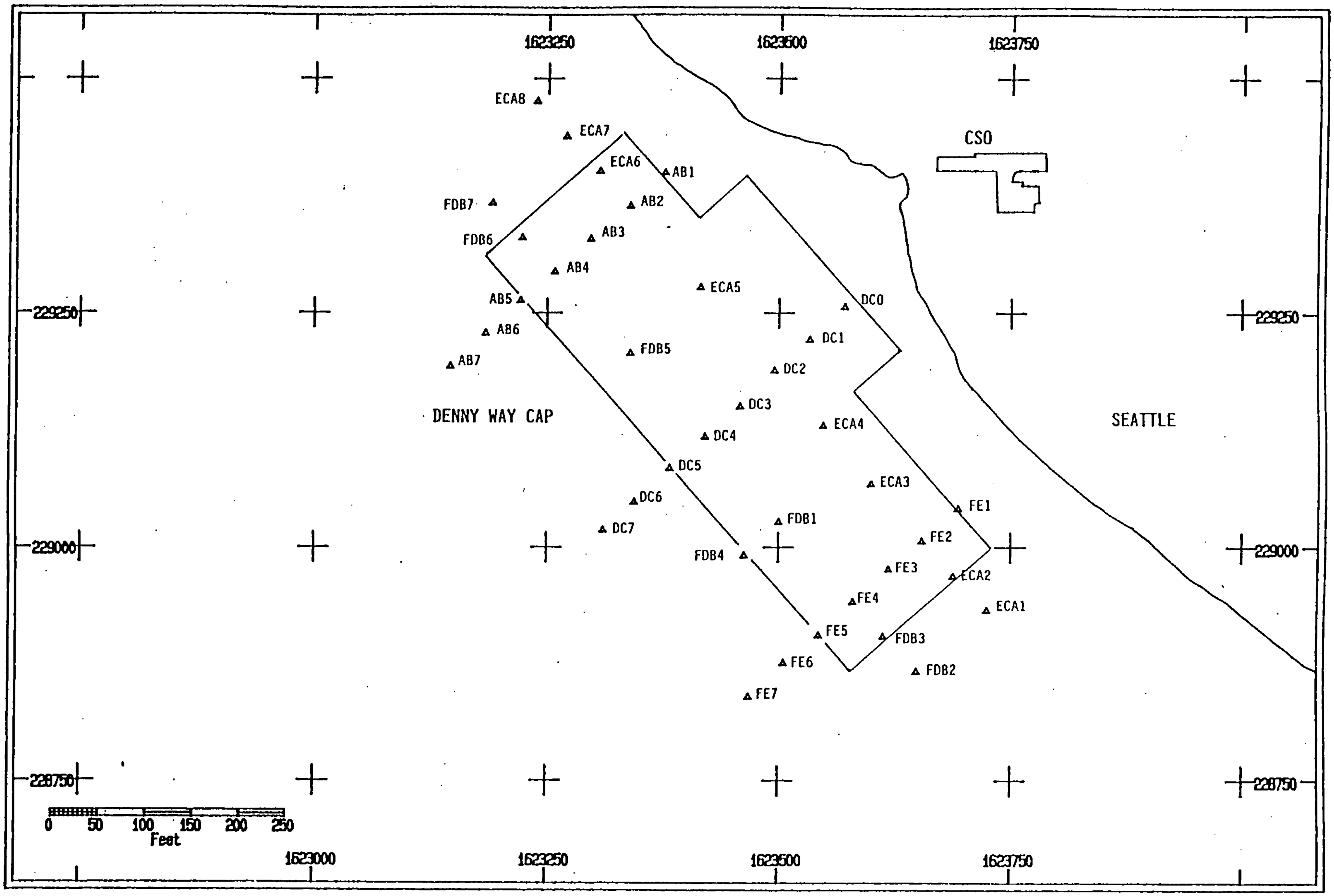

Figure 2-2. The target sampling grid occupied during the October 1991 Denny Way CSO cap survey. The grid consistes of three cross-slope transects and two along-slope transects.

chosen in consultation with METRO to afford spatial coverage of the cap area and to best assess the biological conditions existing upon the cap. The locations of these 24 REMOTS® are mapped in Figure 2-3. Image FDB7/A is mapped as the target sampling station because the location of acquisition is not available.

In addition to the sediment profile images obtained during the survey and the subsequent image analysis, plan view photographs were collected. Due to a problem with the strobe timing mechanism, the plan view images obtained exhibited insufficient illumination of the seafloor. This precluded analysis of the plan view photographs and subsequent correlation with the sediment profile images.

2.1.1 Navigation and Positioning

All positioning support was provided by METRO and consisted of a team of land-based surveyors using a laser theodolite range-azimuth positioning system. The surveyors occupied a known horizontal control point, and by monitoring the range and azimuth to a prism on the stern of the vessel, they directed the vessel to target sampling locations by radio. Uninterrupted communication between the surveying team and the vessel's helmsman was maintained during sampling operations. Prior to deployment of the sediment profile camera, a series of surface buoys were deployed at bottom stake locations to visually aid the helmsman and crew throughout the survey day. Once the surveyors and helmsman guided the vessel to the desired location, the sediment profile camera was lowered to the bottom. When the camera touched bottom, as evidenced by winch wire slack, the surveying team was notified and the range and azimuth of the vessel to the horizontal control point were recorded. Sampling locations, expressed as northings and eastings (Lambert State Plane, Washington North Zone), were provided to SAIC at a later date. The locations of all images, for which positions are available, are presented in Table 2-1 and mapped relative to the capped area in Figure 2-4.

2.1.2 REMOTS® Sediment Profile Images

REMOTS® images were taken using a Benthos Model 3731 Sediment-Profile Camera (Benthos Inc. North Falmouth, MA; Figure 2-5). The camera consists of a wedge-shaped prism with a plexiglass face plate; light is provided by an internal strobe. The back of the prism has a mirror mounted at a 45° angle to reflect the profile of the sediment-water interface up to the camera which is mounted horizontally on the top of the prism. The prism is filled with distilled water, and because the object to be photographed is directly against the face plate, turbidity of the ambient seawater is not a limiting factor. The bottom edge of the optical prism (shaped like an inverted periscope) consists of a blade to minimize sediment disturbance when vertically intersecting the bottom. The camera prism is mounted on an assembly that can be moved up and

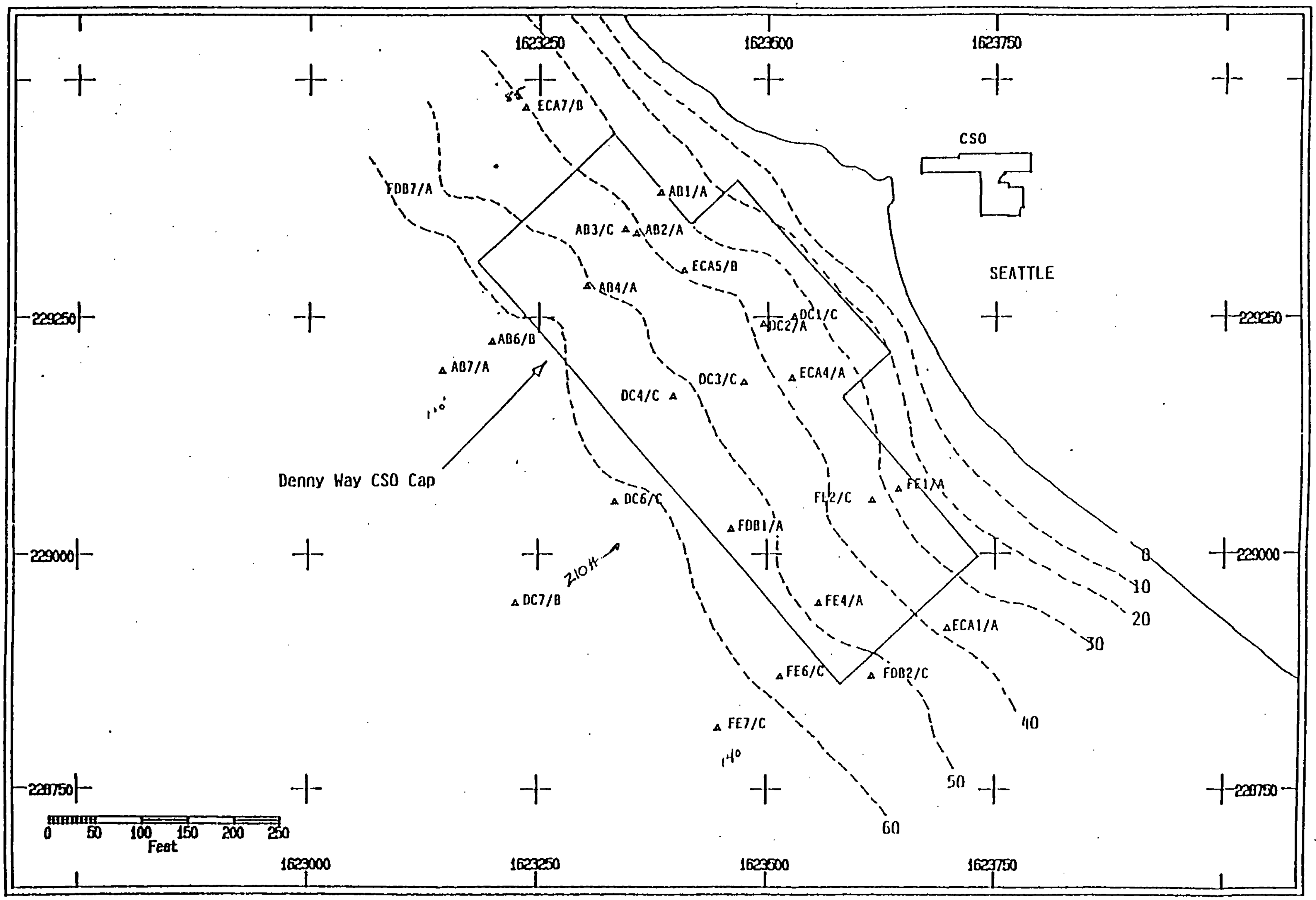

Figure 2-3. The locations of the twenty-four images selected for image analysis. The images are identified by station number and replicate. Note that for the analyzed replicate image FDB7/A no position was recorded. This station however, is north-northwest of the Denny Way cap boundary. Water depths are in feet (MLLW).

Table 2-1. Locations of stations occupied during the October Denny Way CSO Cap Survey.

STATION	LATITUDE	LONGITUDE	NORTHING	EASTING
AB1/A	37° 44.975'N	122°18.239'W	1623383	229383.7
AB1/B	47° 37.118'N	122°17.741'W	1623336	229398.5
AB1/C	NA	NA	NA	NA
AB2/A	47° 37.109'N	122°21.634'W	1623356	229342
AB2/B	47° 37.116'N	122°21.631'W	1623366	229384
AB3/A	47° 37.105'N	122°21.638'W	1623337	229384
AB3/B	47° 37.106'N	122°21.639'W	1623334	229324
AB3/C	47° 37.110'N	122°21.637'W	1623344	229346
AB4/A	47° 37.100'N	122°21.646'W	1623302	229284
AB4/B	47° 37.097'N	122°21.648'W	1623296	229270
AB4/C	47° 37.102'N	122°21.648'W	1623296	229301
AB5/A	47° 37.091'N	122°21.654'W	1623269	229234
AB5/B	47° 37.087'N	122°21.652'W	1623276	229211
AB5/C	47° 37.092'N	122°21.653'W	1623274	229237
AB6/A	47° 37.089'N	122°21.671'W	1623199	229224
AB6/B	NA	NA	NA	NA
AB6/C	NA	NA	NA	NA
AB7/A	47° 37.084'N	122°21.684'W	1623145	229193
AB7/B	47° 37.083'N	122°21.681'W	1623159	229187
AB7/C	47° 37.086'N	122°21.682'W	1623155	229105

Table 2-1. Locations of stations occupied during the October 1991 Denny Way CSO Cap survey. (Continued).

STATION	LATITUDE	LONGITUDE	NORTHING	EASTING
DC0/A	47° 37.106'N	122°21.588'W	1623543	229317
DC0/B	47° 37.102'N	122°21.583'W	1623564	229292
DC0/C	47° 37.109'N	122°21.583'W	1623562	229339
DC1/A	47° 37.103'N	122°21.591'W	1623530	229298
DC1/B	47° 37.097'N	122°21.590'W	1623535	229261
DC1/C	47° 37.095'N	122°21.591'W	1623529	229250
DC2/A	47° 37.093'N	122°21.599'W	1623495	229242
DC2/B	47° 37.091'N	122°21.601'W	1623488	229229
DC2/C	47° 37.092'N	122°21.601'W	1623486	229223
DC3/A	47° 37.082'N	122°21.606'W	1623466	229173
DC3/B	47° 37.081'N	122°21.604'W	1623475	229169
DC3/C	47° 37.083'N	122°21.604'W	1623474	229181
DC4/A	47° 37.080'N	122°21.622'W	1623402	229161
DC4/B	47° 37.082'N	122°21.619'W	1623414	229172
DC4/C	47° 37.081'N	122°21.623'W	1623397	229167
DC5/A	47° 37.070'N	122°21.626'W	1623383	229104
DC5/B	47° 37.070'N	122°21.626'W	1623382	229102
DC5/C	47° 37.070'N	122°21.626'W	1623382	229104
DC6/A	47° 37.061'N	122°21.637'W	1623335	229046
DC6/B	47° 37.065'N	122°21.633'W	1623355	229074
DC6/C	47° 37.062'N	122°21.638'W	1623334	229056
DC7/A	47° 37.045'N	122°21.662'W	1623230	228953
DC7/B	47° 37.044'N	122°21.663'W	1623226	228949
DC7/C	47° 37.044'N	122°21.664'W	1623225	228949

Table 2-1. Locations of stations occupied during the October 1991 Denny Way CSO Cap survey. (Continued).

STATION	LATITUDE	LONGITUDE	NORTHING	EASTING
FE1/A	47° 37.065'N	122°21.562'W	1623644	229069
FE1/B	47° 37.065'N	122°21.558'W	1623662	229067
FE1/C	47° 37.064'N	122°21.553'W	1623680	229063
FE2/A	47° 37.066'N	122°21.572'W	1623605	229074
FE2/B	47° 37.060'N	122°21.575'W	1623590	229038
FE2/C	47° 37.063'N	122°21.569'W	1623615	229057
FE3/A	47° 37.052'N	122°21.570'W	1623609	228986
FE3/B	47° 37.053'N	122°21.568'W	1623617	228995
FE3/C	47° 37.050'N	122°21.567'W	1623623	228978
FE4/A	47° 37.045'N	122°21.583'W	1623557	228949
FE4/B	47° 37.049'N	122°21.583'W	1623556	228974
FE4/C	47° 37.051'N	122°21.583'W	1623559	228983
FE5/A	47° 37.040'N	122°21.591'W	1623521	228918
FE5/B	47° 37.037'N	122°21.589'W	1623532	228902
FE5/C	47° 37.036'N	122°21.594'W	1623511	228891
FE6/A	47° 37.035'N	122°21.590'W	1623528	228885
FE6/B	47° 37.032'N	122° 21.589'W	1623532	228869
FE6/C	47° 37.032'N	122°21.593'W	1623515	228872
FE7/A	47° 37.025'N	122°21.614'W	1623426	228827
FE7/B	47° 37.022'N	122°21.606'W	1623457	228811
FE7/C	47° 37.023'N	122°21.609'W	1623447	228816

Table 2-1. Locations of stations occupied during the October 1991 Denny Way CSO Cap survey. (Continued).

STATION	LATITUDE	LONGITUDE	NORTHING	EASTING
ECA1/A	47° 37.041'N	122°21.548'W	1623698	228923
ECA1/B	47° 37.045'N	122°21.552'W	1623682	228943
ECA1/C	NA	NA	NA	NA
ECA2/A	47° 37.054'N	122°21.554'W	1623677	228999
ECA2/B	47° 37.056'N	122°21.557'W	1623664	229012
ECA3/A	47° 37.070'N	122°21.580'W	1623570	229100
ECA3/B	47° 37.069'N	122°21.577'W	1623582	229096
ECA4/A	47° 37.084'N	122°21.591'W	1623527	229185
ECA4/B	47° 37.082'N	122°21.592'W	1623523	229172
ECA5/A	47° 37.102'N	122°21.622'W	1623401	229300
ECA5/B	47° 37.103'N	122°21.621'W	1623408	229301
ECA6/A	47° 37.128'N	122°21.668'W	1623216	229462
ECA6/B	47° 37.130'N	122°21.665'W	1623230	229472
ECA6/C	47° 37.124'N	122°21.645'W	1623309	229433
ECA6/D	47° 37.125'N	122°21.695'W	1623107	229442
ECA7/A	47° 37.124'N	122°21.645'W	1623311	229432
ECA7/B	47° 37.130'N	122°21.664'W	1623235	229471
ECA8/A	47° 37.155'N	122°21.680'W	1623170	229624
ECA8/B	47° 37.152'N	122°21.690'W	1623130	229607
FDB1/A	47° 37.058'N	122°21.607'W	1623641	229027
FDB1/B	47° 37.063'N	122°21.597'W	1623501	229056
FDB2/A	47° 37.033'N	122° 21.563'W	1623635	228872
FDB2/B	47° 37.034'N	122°21.561'W	1623644	228881
FDB2/C	47° 37.033'N	122°21.568'W	1623615	228872
FDB3/A	47° 37.040'N	122°21.578'W	1623576	228914
FDB3/B	47° 37.041'N	122°21.579'W	1623571	228924
FDB3/C	47° 37.040'N	122°21.580'W	1623566	228917
FDB4/A	47° 37.056'N	122°21.618'W	1623414	229014

Table 2-1. Locations of stations occupied during the October 1991 Denny Way CSO Cap survey. (Continued).

STATION	LATITUDE	LONGITUDE	NORTHING	EASTING
FDB4/B	47° 37.053'N	122°21.621'W	1623403	229001
FDB5/A	47° 37.091'N	122°21.642'W	1623321	229223
FDB5/B	47° 37.091'N	122°21.646'W	1623301	229233
FDB6/A	47° 37.119'N	122°21.670'W	1623208	229404
FDB6/B	47° 37.120'N	122°21.665'W	1623227	229413
FDB6/C	47° 37.119'N	122°21.670'W	1623208	229406
FDB7/A	NA	NA	NA	NA
FDB7/B	NA	NA	NA	NA
S1/A	47° 37.106'N	122°21.599'W	1623498	229321
S1/B	47° 37.115'N	122°21.599'W	1623500	229372
S1/C	47° 37.111'N	122°21.613'W	1623440	229349
S1/D	47° 37.120'N	122°21.612'W	1623446	229408

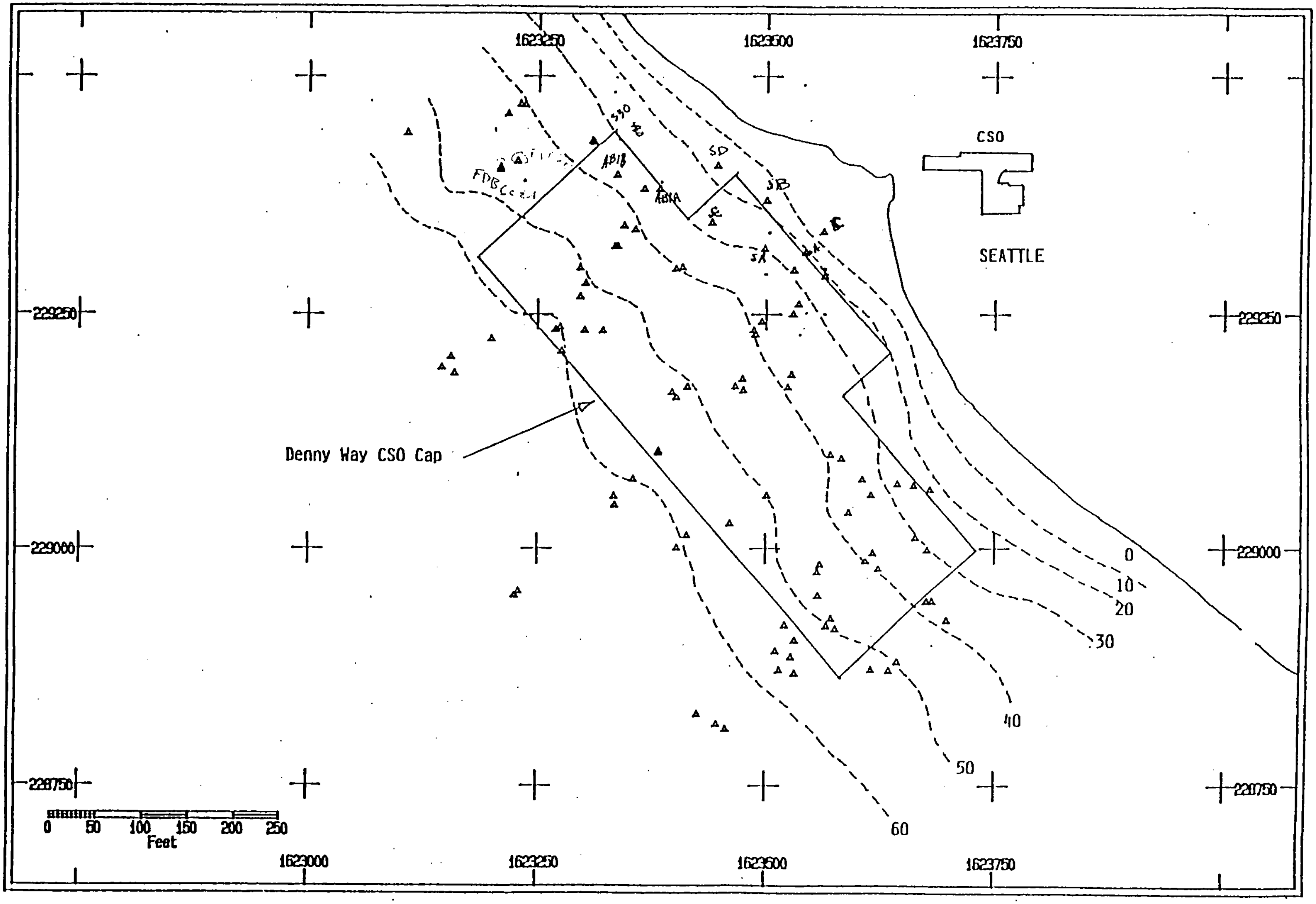

Figure 2-4. The locations of sediment profile images collected during the October Denny Way CSO cap survey. Not all replicates are shown in this figure as positions for some replicates were not recorded. All depths are in feet (MLLW).

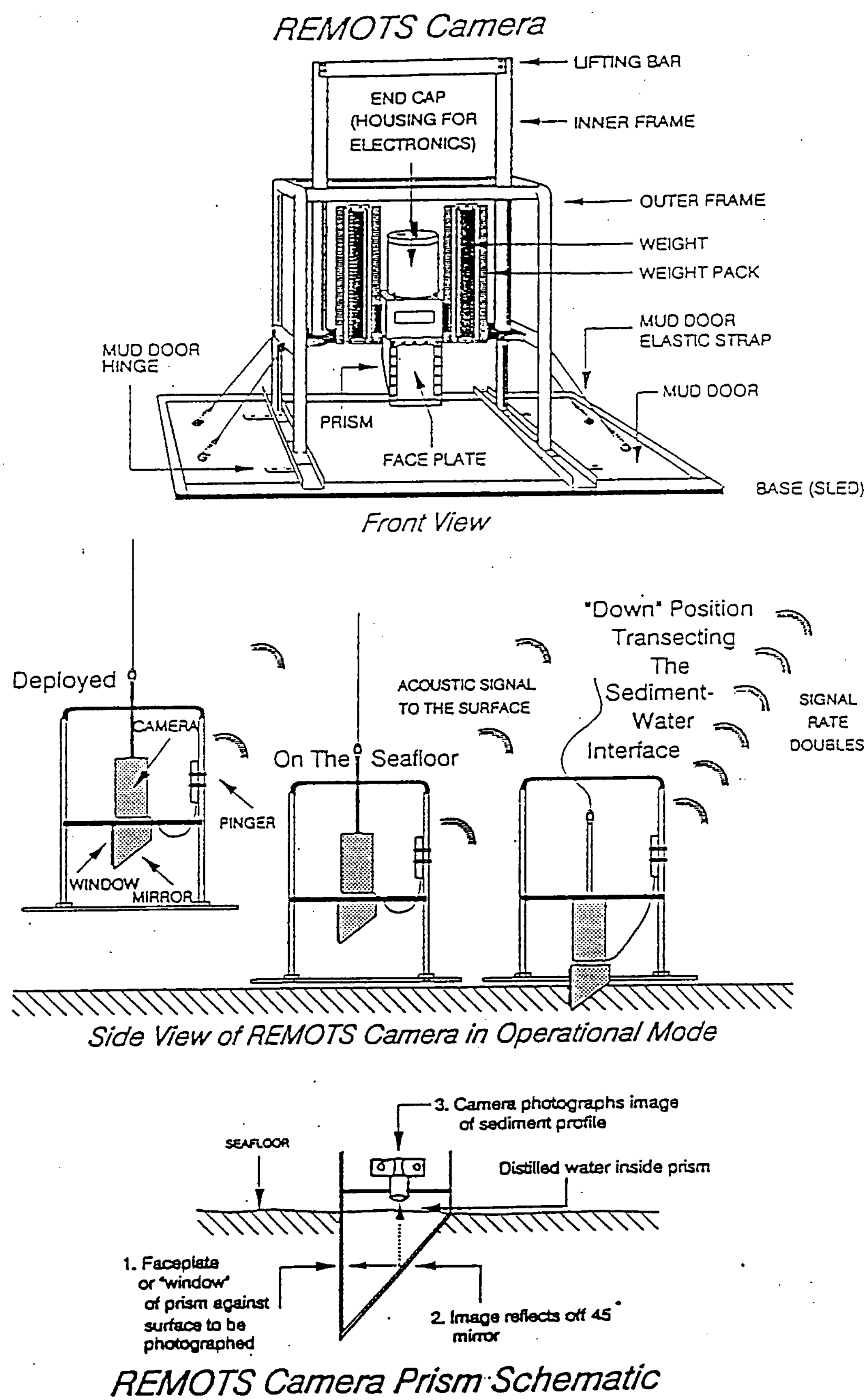

Figure 2-5. The Benthos Model 3731 Sediment Profile Camera.

down by allowing tension or slack on the winch wire. As the camera is lowered, tension on the winch wire keeps the prism in the up position. A wide bearing frame contacts the bottom first, leaving the area directly under the prism undisturbed. Once the camera frame touches the bottom, slack on the winch wire allows the prism to vertically intersect the seafloor.

The rate of fall of the optical prism into the bottom is controlled by an adjustable "passive" hydraulic piston. This allows the optical prism to enter the bottom at approximately 6 cm/sec. This slow fall rate minimizes disturbance of the sediment-water interface. The prism is driven several centimeters into the seafloor by the weight of the assembly. The camera trigger is tripped on impact with the bottom, activating a 13-second time delay on the shutter release; this gives the prism a chance to obtain maximum penetration before a photo is taken. As the camera is raised to a height of about ten feet from the bottom, a wiper blade automatically cleans off any sediment adhering to the prism faceplate; the film is automatically advanced by a motor drive, the strobes are recharged, and the camera can be lowered for another replicate image. When the camera is brought to the surface, optical prism penetration is measured from a penetration indicator which measures the distance the prism falls relative to the camera base. If penetration is inadequate, two weight packs, each capable of holding 125 lbs of lead (in 25 lb increments), can be loaded to increase penetration (e.g., for work in sandy or high shear strength, compacted sediments). If penetration is too great, adjustable stops, which control the distance the prism can descend, can be lowered, and "mud"doors can be attached to each side of the frame to increase the bearing surface of the entire unit. For this survey, four weights per pack (total of 200 pounds) were used at all stations except AB7 and DC7, at which no weights were used.

2.2 Sample Analysis

2.2.1 Sediment Profile Image Analysis

All images were taken with Ektachrome ASA 50D, color slide film. As the field survey was one day, film was developed at the laboratory after survey completion. Duplicates of all color slides obtained for this report are provided separately as Appendix B.

In the laboratory, REMOTS® measurements of all physical and some biological parameters were measured directly from the color transparencies using a video digitizer and computer image analysis system. The slides are used for analysis instead of positive prints in order to avoid changes in image density that can accompany the printing of an enlarged, positive image. The image analysis system can discriminate up to 256 different tonal scales, so subtle features can be digitized and measured accurately. Proprietary software allows the measurement and storage of data on up to 21 different variables for each REMOTS® image. Before all measurements from each REMOTS® image are stored on disk, a summary display is made on the screen so the operator can verify if the values stored in memory for each variable are within expected ranges; if anomalous values are detected, software options allow remeasurement before storage on disk. All data stored on disks are printed out on data sheets for QA/QC verification and editing by a senior-level scientist. Following this review, data are edited before final synthesis, statistical analyses, and interpretation. Computer storage of all parameters allows data from any variables of interest to be compiled, sorted, displayed graphically, contoured, or compared statistically. A REMOTS® data sheet for each image analyzed is included in Appendix A. Specific measurement techniques and the interpretative framework for the REMOTS® parameters evaluated in this survey are presented below.

Sediment Type: The sediment grain size major mode and range are visually estimated from the projected slides by overlaying a grain size comparator which is at the same scale. This comparator was prepared by photographing a series of Udden-Wentworth size classes (equal to or less than coarse silt up to granule and larger sizes) through the REMOTS® optical system. Seven grain size classes are on this comparator: ≥ 4 phi, 4-3 phi, 3-2 phi, 2-1 phi, 1-0 phi, 0-(-)1 phi, < -1 phi. The lower limit of optical resolution of the photographic system is about 62 microns, allowing recognition of grain sizes equal to or greater than coarse silt. The accuracy of this method has been documented by comparing REMOTS® estimates with grain size statistics determined from laboratory sieve analyses (SAIC, 1986a).

Prism Penetration Depth: The prism penetration depth is determined by measuring both the largest and smallest linear distance between the sediment-water interface and the bottom of the film frame. The REMOTS® analysis software automatically averages these maximum and minimum values to determine the average penetration depth. All three values, (maximum, minimum, and average penetration depth) are included on the data sheets (Appendix A). Comparative penetration depths from stations of similar grain size give an indication of relative sediment water-content and shear strength.

Surface Boundary Roughness: Surface boundary roughness is determined by measuring the vertical distance between the highest and lowest points of the sediment-water interface. In addition, the origin (e.g., physical or biogenic) of this small-scale topographic relief is indicated when it is apparent. In sandy sediments, boundary roughness can be a measure of sand ripple height. On silt-clay bottoms, boundary roughness values often reflect biogenic features such as fecal mounds or surface burrows. Disposed dredged material often introduces high surface relief on an otherwise "smooth" bottom.

Mud Clasts: When fine-grained, cohesive sediments are disturbed, either by physical bottom scour or faunal activity (e.g., decapod foraging), intact clumps of sediment are often scattered about the seafloor. Following dredged material disposal, relict sediment clumps also may be present on the seafloor. These mud or clay clasts can be seen at the sediment-water interface in REMOTS® images. During analysis, the number of clasts is counted, the diameter of a typical clast is measured, and their oxidation state is assessed. Depending on their place of origin, mud clasts can be reduced or oxidized (in REMOTS® images, the oxidation state is apparent from the reflectance value; see RPD section below). These sediment clumps are subject to bottom-water oxygen concentrations and bottom currents. Based on laboratory microcosm observations of reduced sediments placed within an aerobic environment, oxidation of reduced surface layers to depths of one to two millimeters by diffusion alone is quite rapid, occurring within 6-12 hours (Germano, 1983). Consequently, the detection of reduced mud clasts in an obviously aerobic setting suggests a recent origin. The size and shape of mud clasts, e.g. angular versus rounded, also is considered. Mud clasts may be moved about and broken by bottom currents and/or animals (macro- or meiofauna; Germano, 1983). Over time, large angular clasts become small and rounded. Overall, the abundance, distribution, oxidation state, and appearance of mud clasts are used to make inferences about the recent pattern of seafloor disturbance. Care is taken to exclude clasts that may be an artifact of the camera.

Apparent Redox Potential Discontinuity (RPD) Depth: Aerobic near-surface, fine-grained sediments have a higher reflectance value relative to underlying hypoxic or anoxic sediments. This is readily apparent in REMOTS® images and is due to oxidized surface sediment that contains particles coated with ferric hydroxide (an olive brown color when associated with particles), while the reduced sediments below this oxygenated layer are generally grey to black. The boundary between the colored ferric hydroxide surface sediment and underlying grey to black sediment is called the apparent redox potential discontinuity (abbreviated as the RPD). The average depth of this boundary in each image is measured.

The depth of the apparent RPD in the sediment column is an important time-integrator of dissolved oxygen conditions within sediment pore waters. In the absence of bioturbating organisms, this high reflectance layer (in muds) will be typically one to three mm thick (Rhoads, 1974). This depth is related to the rate of supply of molecular oxygen (by Fickian diffusion) into the bottom, and the consumption of that oxygen by the sediment and associated microflora. In sediments which have very high sediment-oxygen demand (SOD), the sediment may lack a high reflectance layer even when the overlying water column is aerobic. In the presence of bioturbating macrofauna, the thickness of the high reflectance layer may be several centimeters thick. The relationship between the thickness of this high reflectance layer and the presence or absence of free molecular oxygen in the associated pore waters must be made with caution. The boundary (or horizon) which separates the positive Eh region of the sediment column from the underlying negative Eh region is called the Redox Potential Discontinuity or RPD. The exact location of this Eh=0 potential only can be determined accurately with microelectrodes; hence the relationship between the change in optical reflectance, as imaged with the REMOTS® camera, and the actual RPD only can be determined by making the appropriate in situ Eh measurements. For this reason, we describe the optical reflectance boundary, as imaged, as the apparent RPD. In general, the depth of the actual Eh=0 horizon will be shallower than the depth of the optical reflectance boundary. This is because bioturbating organisms can mix ferric hydroxide-coated particles downward into the bottom below the Eh=0 horizon. As a result, the apparent mean RPD depth can be considered an estimate of the extent of biogenic sediment mixing, including pore water irrigation.

The depression of the apparent RPD within the sediment is relatively slow in organic-rich muds (on the order of 200 to 300 micrometers per day), therefore this parameter has a long time constant (Germano and Rhoads, 1984). The rebound in the apparent RPD is also slow (Germano, 1983). Measurable changes in the apparent RPD depth using the REMOTS® optical technique can be detected over periods of one or two months. This parameter has been used effectively to document changes (or gradients) which develop over a seasonal or yearly cycle as related to water temperature effects on bioturbation rates, seasonal hypoxia, sediment oxygen demand, and infaunal recruitment (SAIC, 1986b). In sediment-profile surveys of ocean disposal sites throughout New England performed under the DAMOS program for the U.S. Army Corps of Engineers (SAIC, 1986c; SAIC, 1986d), it has been documented repeatedly that a drastic reduction in apparent RPD depths at disposal sites occurs immediately after dredged material dumping. This is followed by a progressive post-disposal apparent RPD deepening (barring further disposal activity). Consequently, time series RPD measurements can be a critical diagnostic element in monitoring the degree of recolonization in an area by the ambient benthos.

Another important characteristic of the apparent RPD is the contrast in reflectance values across this boundary. This contrast is related to the inventory of reactive organic matter, bioturbation, and bottom-water dissolved oxygen levels. High inputs of labile organic material increase sediment oxygen demand and sulphate reduction rates (and the abundance of sulphidic end-products). This results in more highly reduced (lower-reflectance) sediments at depth and higher RPD contrasts. Images with high RPD contrasts indicate localized sites of relatively high inputs of organic-rich material (e.g. dredged material or sewage input).

Infaunal Successional Stage: The mapping of successional stages from REMOTS® images is based on the theory that organism-sediment interactions follow a predictable sequence after a major seafloor perturbation. This theory states that primary succession results in "the predictable appearance of macrobenthic invertebrates belonging to specific functional types following a benthic disturbance. These invertebrates interact with sediment in specific ways. Because functional types are the biological units of interest..., our definition does not demand a sequential appearance of particular invertebrate species or genera" (Rhoads and Boyer, 1982). This theory is formally developed in Rhoads and Germano (1982) and Rhoads and Boyer (1982).

The term disturbance is used here to define natural processes, such as seafloor erosion, changes in seafloor chemistry, foraging disturbances which cause major changes in the resident benthos; or anthropogenic impacts, such as dredged material or sewage sludge dumping, thermal effluents from power plants, or pollution impacts from industrial discharge. An important aspect of using this successional approach to interpret benthic monitoring results involves linking organism-sediment relationships to the successional dynamics. This involves deducing dynamics from structure, a technique pioneered by R. G. Johnson (1972) for marine soft-bottom habitats. The application of an inverse methods approach to benthic monitoring requires in-situ measurements of the salient structural features of organism-sediment relationships such as those imaged using REMOTS® technology.

Pioneering assemblages (stage I assemblages) usually consist of dense aggregations of near-surface living, tube-dwelling polychaetes; alternately, opportunistic mactrid bivalves (e.g., Mulinia) may colonize initially in dense aggregations after a disturbance (Rhoads and Germano, 1982, Santos and Simon, 1980b). These functional types usually are associated with a shallow redox boundary; bioturbation depths are shallow, particularly in the earliest stages of colonization. In the absence of further disturbance, these early successional assemblages are eventually replaced by infaunal deposit feeders; the start of this "infaunalization" process is designated arbitrarily as stage II. Typical stage II species are shallow dwelling bivalves or, as is common in areas such as the northeast U.S., tubicolous amphipods (SAIC, 1986d). Amphipods appear to participate in the Tampa Bay successional sequence in a similar way. In studies of hypoxia-induced benthic defaunation events in Tampa Bay, ampeliscid amphipods appeared as the second temporal dominant in two of the four recolonization cycles (Santos and Simon, 1980a and 1980b). Stage III taxa, in turn, represent high-order successional stages typically found in low disturbance regimes. These invertebrates are infaunal, and many feed at depth in a head-down orientation. The localized feeding activity results in distinctive excavations called feeding voids. Diagnostic features of these feeding structures include: a generally semicircular shape with a flat bottom and arched roof, and a distinct granulometric change in the sediment particles overlying the floor of the structure. This coarse-grained material represents particles rejected by the head-down deposit-feeder, as these deep-dwelling infaunal taxa preferentially ingest the finer sediment particles. Other subsurface structures, e.g. burrows or methane gas bubbles, do not exhibit these characteristics. The bioturbational activities of these deposit-feeders are responsible for aerating the sediment and causing the apparent RPD to be located several centimeters below the sediment-water interface. In the retrograde transition of stage III to stage I, it is sometimes possible to recognize the presence of relict (i.e., collapsed and inactive) feeding voids. Stages I and III are easily recognized in REMOTS® images by the presence of dense assemblages of near-surface polychaetes and/or the presence of subsurface feeding voids, respectively; both types of assemblages may be present in the same image. The ability of REMOTS® to map benthic succession has been reviewed and confirmed by Grizzle and Penniman (1991).

REMOTS® Organism-Sediment Index: A multi-parameter REMOTS® Organism-Sediment Index (OSI) has been constructed to characterize benthic habitat quality. Habitat quality is defined relative to two end-member standards. The lowest value is given to those bottoms which have low or no dissolved oxygen in the overlying bottom water, no apparent macrofaunal life, and methane gas present in the sediment (see Rhoads and Germano, 1982 and 1986 for REMOTS® criteria for these conditions). The REMOTS® Organism-Sediment Index for such a condition is defined as minus 10. At the other end of the scale, an aerobic bottom with a deeply depressed RPD, evidence of a mature macrofaunal assemblage, and no apparent methane gas bubbles at depth has a REMOTS® OSI value of plus 11. The REMOTS® Organism-Sediment Index is arrived at by summing the subset indices shown in Table 2-2. The organism-sediment index is calculated automatically by the REMOTS® image analysis software after completion of all measurements from each negative or slide. This index has been a useful parameter for mapping disturbance gradients in an area and documenting ecosystem recovery after disturbance (Germano and Rhoads, 1984; Rhoads and Germano, 1986; SAIC, 1986c).

Table 2-2. Calculation of the Organism-Sediment Index

CHOOSE ONE VALUE:

Mean RPD Depth Classes		Index Value
	0.00 cm	0
> 0 -	0.75 cm	1
0.76 -	1.50 cm	2
1.51 -	2.25 cm	3
2.26 -	3.00 cm	4
3.01 -	3.75 cm	5
>	3.75 cm	6

CHOOSE ONE VALUE:

Successional Stage	Index Value
Azoic	- 4
Stage I	1
Stage I – II	2
Stage II	3
Stage II – III	4
Stage III	5
Stage I on III	5
Stage II on III	5

CHOOSE ONE OR BOTH IF APPROPRIATE:

Chemical Parameters	Index Value
Methane Present	- 2
No/Low Dissolved Oxygen	- 4

REMOTS® ORGANISM-SEDIMENT INDEX = Total of above subset indices

RANGE: - 10 to +11

3.0 RESULTS

The following section focuses on the results of the sediment profile image analysis and the features observed from the entire set of sediment profile images. The results of image analysis of the 24 selected stations are summarized in Table 3-1. Throughout this section, maps depicting the distribution of selected REMOTS® parameters at each station (grain size major-mode, prism penetration, apparent redox potential discontinuity (RPD) depth, infaunal successional stage and organism-sediment index (OSI)) are presented to aid in the spatial evaluation of the data. REMOTS® parameters are mapped at the locations recorded for the analyzed replicate.

3.1 Physical/Sedimentary Features

The Denny Way CSO cap is characterized by medium to coarse sands exhibiting generally poor sorting. The distribution of grain size major-modes is mapped in Figure 3-1. The cap consists predominantly of 3-2 phi fine sands although some of the stations in shallower water exhibit coarser grained major-modes of 2-1 phi (medium sand). For the stations which exhibit grain size major-modes of 3-2 phi, the sands observed within these images are skewed towards the coarser fraction of this grain size class (eg. closer to 2ϕ than 3ϕ). Images exhibiting typical cap material and bottom conditions adjacent to the cap are presented as Figures 3-2 to 3-5.

In addition to grain size, the composition of the cap sands has a distinct signature. The cap sands exhibit a mix of high and low reflectance material. Interspersed between the sands is fine grained material. The degree of sorting varies widely within and between stations. A distinguishing characteristic of the capping sands is the presence of rounded, reddish granules which are interpreted to be pieces of broken and weathered brick. These granules may be observed in images presented in Figures 3-2 through 3-4. Other distinguishing characteristics of the dredged material used for the cap are leaf and twig debris coating the sediment surface and cohesive clasts of fine grained dredged material.

The dredged material used for capping is observed in nearly all images. However, capping materials are not seen at Stations S (three of four replicates), ECA8 (both replicates) and DC0 (replicates A and B). Offshore of the cap boundary, at Stations AB7, DC7, and FE7, a thin layer of cap material is observed overlying native sediments. These three stations are characterized by a layer of very fine to fine sands, overlying lower reflectance, gray silt/clays. Although there is no baseline or control data regarding the physical properties of the native sediments outboard of the cap boundary prior to cap emplacement, the thin layer of coarse sands present at the seaward stations is interpreted to be cap material. The presence

Table 3-1. REMOTS® parameters measured from twenty-four Denny Way CSO cap images.

STATION	GRAIN SIZE	RANGE	PEN	BR	RPD	SUCC.STG	OSI	COMMENT
AB1/A	2 - 1 φ	4 - 0 φ	6.27	1.36	IND	IND	IND	DM>P,
AB2/A	4 - 3 φ	>4 - 2 φ	10.55	1.02	2.16	I	4	Wood debris
AB3/C	3 - 2 φ	>4 - 2 φ	7.44	1.57	1.91	I	4	DM>P,in situ FE203
AB4/A	3 - 2 φ	4 - 2 φ	4.58	0.68	1.65	I	4	DM>P, FE203 coated tubes
AB6/B	3 - 2 φ	4 - 2 φ	13.18	1.78	4.19	I	7	DM>P, gas escape chambers, tubes
AB7/A	3 - 2 φ	>4 - 2 φ	15.27	0.81	4.53	I	7	Surface sand layer
DC1/C	3 - 2 φ	4 - 2 φ	4.85	0.72	0	AZOIC	-7	Plants and shells on surface
DC2/A	2 - 1 φ	3 - 2 φ	4.15	0.42	1.23	I	3	FE203 in situ
DC3/C	3 - 2 φ	3 - 2 φ	4.19	1.69	0.70	I	2	FE203 in situ, bedload transport
DC4/C	3 - 2 φ	>4 - 2 φ	4.60	0.72	1.97	II	6	DM>P, Ripped up tube mats
DC6/C	3 - 2 φ	4 - 2 φ	5.80	0.85	3.18	II	8	DM>P, S/M/S, poor sorting
DC7/B	4 - 3 φ	>4 - 2 φ	13.62	1.40	3.9	I → II	8	DM>P, 5 cm sand layer
FE1/A	3 - 2 φ	3 - 2 φ	2.84	1.10	IND	IND	IND	Plant material, stick, DM>P
FE2/C	3 - 2 φ	3 - 2 φ	4.47	1.31	IND	I	IND	Plant material, DM>P
FE4/A	3 - 2 φ	4 - 2 φ	6.42	0.97	3.47	I	6	DM>P, bedform, hydroids
FE6/C	3 - 2 φ	4 - 2 φ	4.72	0.64	3.33	I	6	DM>P, debris, mud/sand
FE7/C	3 - 2 φ	>4 - 2 φ	5.74	1.23	1.48	I	3	DM>P

Table 3-1. REMOTS® parameters measured from Denny Way CSO cap images. (Continued)

STATION	GRAIN SIZE	RANGE	PEN	BR	RPD	SUCC.STG	OSI	COMMENT
ECA1/A	2 - 1 φ	>4 - 1 φ	7.18	0.97	0.91	I	3	DM>P, mud clast in sand cap
ECA4/A	2 - 1 φ	3 - 1 φ	4.09	0.97	IND	I	IND	FE203 in situ, DM>P
ECA5/B	3 - 2 φ	4 - 2 φ	3.73	1.02	0.95	II	5	DM>P, II Retrograde
ECA7/B	3 - 2 φ	4 - 2 φ	4.24	0.25	IND	IND	IND	Fish and plant debris, low DO
FDB1/A	3 - 2 φ	4 - 2 φ	5.15	0.04	1.80	I	4	DM>P
FDB2/C	3 - 2 φ	4 - 2 φ	4.87	0.34B	1.19	I	3	DM>P, bedforms, M/S
FDB7/A	3 - 2 φ	4 - 2 φ	7.03	0.59	2.58	I	5	DM>P

Pen = prism penetration depth in cm

BR = Boundary Roughness in cm

OSI = organism-sediment index

S/M = sand over mud

RPD = apparent redox potential discontinuity depth in cm

Succ.Stage = infaunal successional stage

DM>P = dredged material thickness exceed penetration

FE2O3 in situ = in situ deposition of FE203

Phi Size (φ)	Millimeters
0	1
1	0.5
2	0.25
3	0.125
4	0.0625

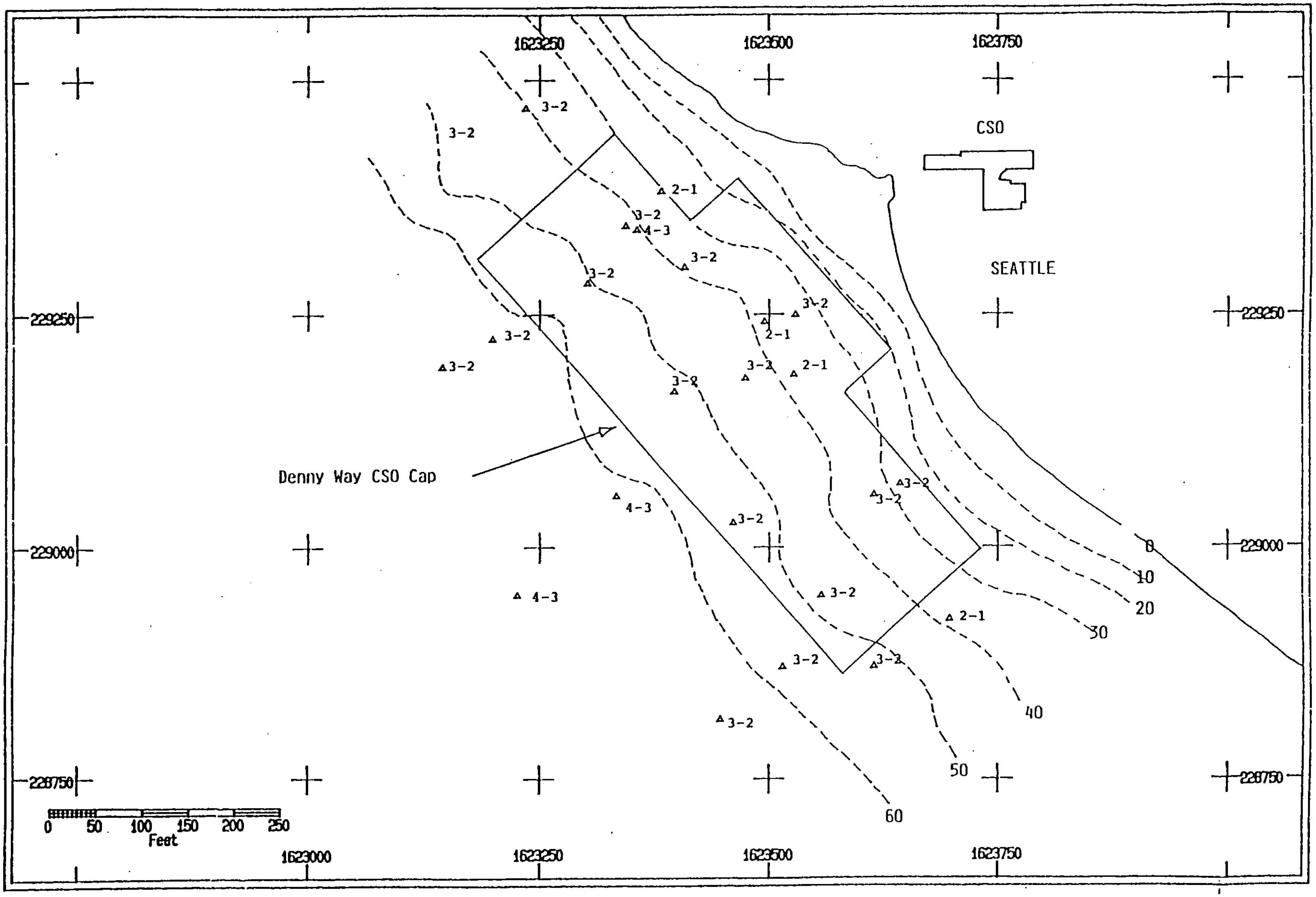

Figure 3-1. The distribution of grain size major-modes measured from the Denny Way CSO cap. Grain size designations are in Wentworth-Udden phi classes (4-3ϕ = very fine sand; 3-2ϕ = fine sand; 2-1ϕ = medium sand). Water depths are in feet (MLLW).

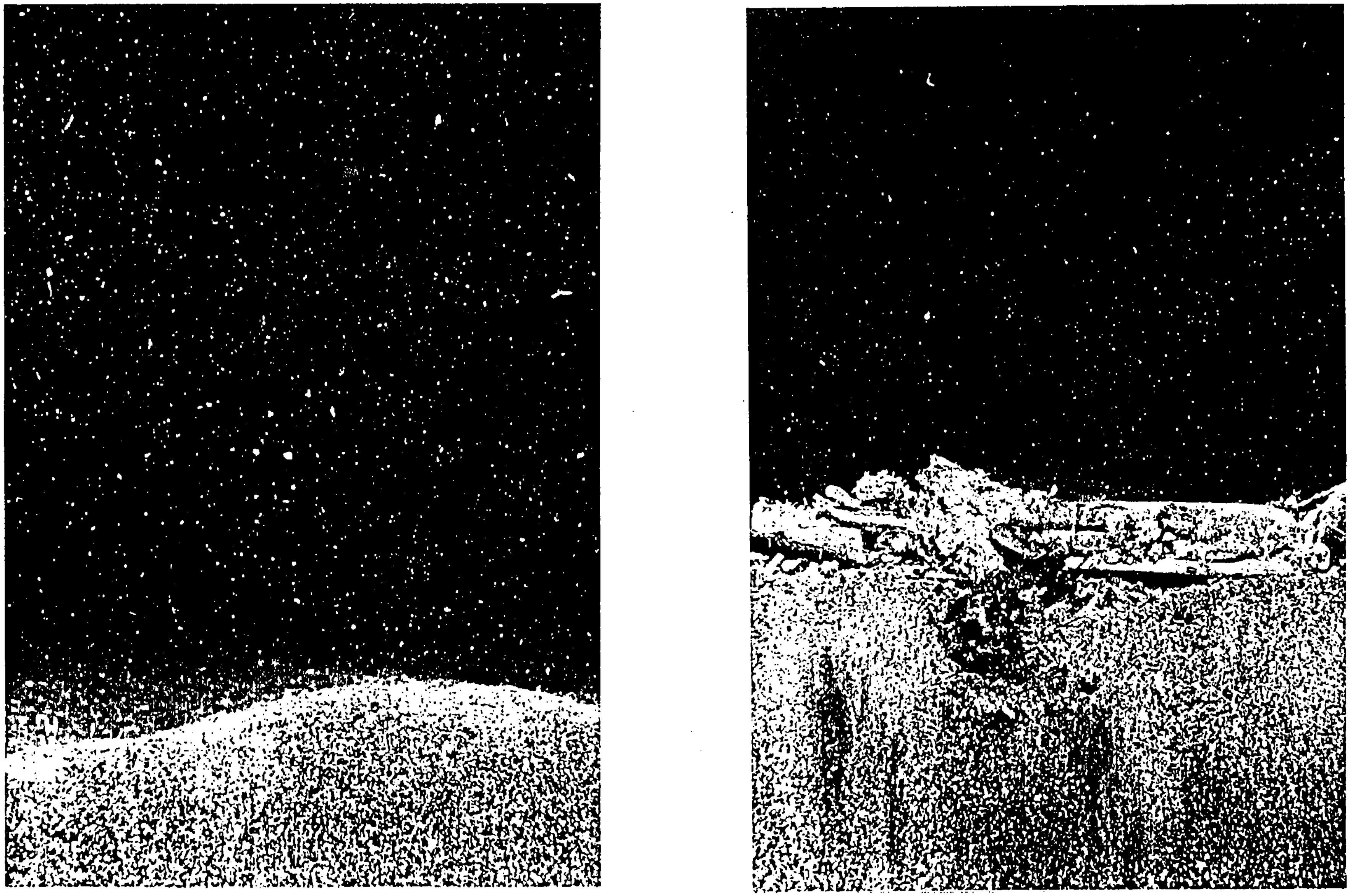

Figure 3-2. REMOTS® images DC3/C (left) and FE2/A showing cap sands. Station DC3/C exhibits well sorted sand with in-situ deposition of Fe_2O_3 coatings on sand grains (tan/rust color) near the sediment surface. Note that there is little or no fine grained material coating the sediment surface in DC3/C and that the sands form a symmetrical current ripple. Image FE2/A shows cap material that is poorly sorted as evidenced by a lens of silt within the sands. Note the presence of wood debris at the sediment surface in FE2/A, as wood and peaty debris are widespread but patchy within the capped area.

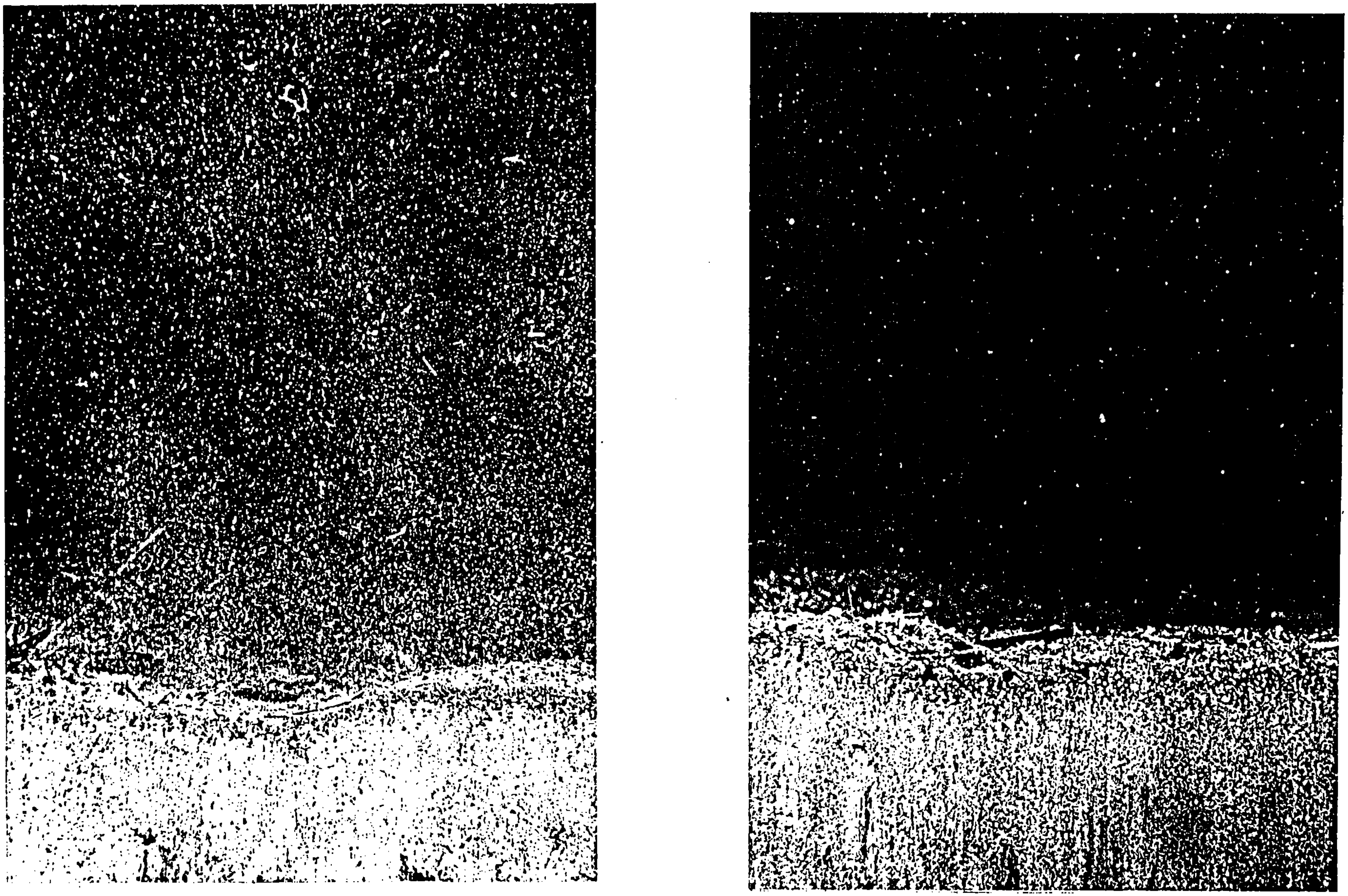

Figure 3-3. REMOTS® images AB4/B (left) and AB5/B. Both of these images exhibit cap material that is poorly sorted. In both images a thin layer of well sorted sands may be seen overlying more poorly sorted material. This suggests that the surficial sand layer is periodically mobile and washed free of fine grained sediment. Low relief bedforms are evident in both images. The sediment surface is covered with wood and peaty debris. The material suspended in the water column are flocculents agitated by the REMOTS® camera.

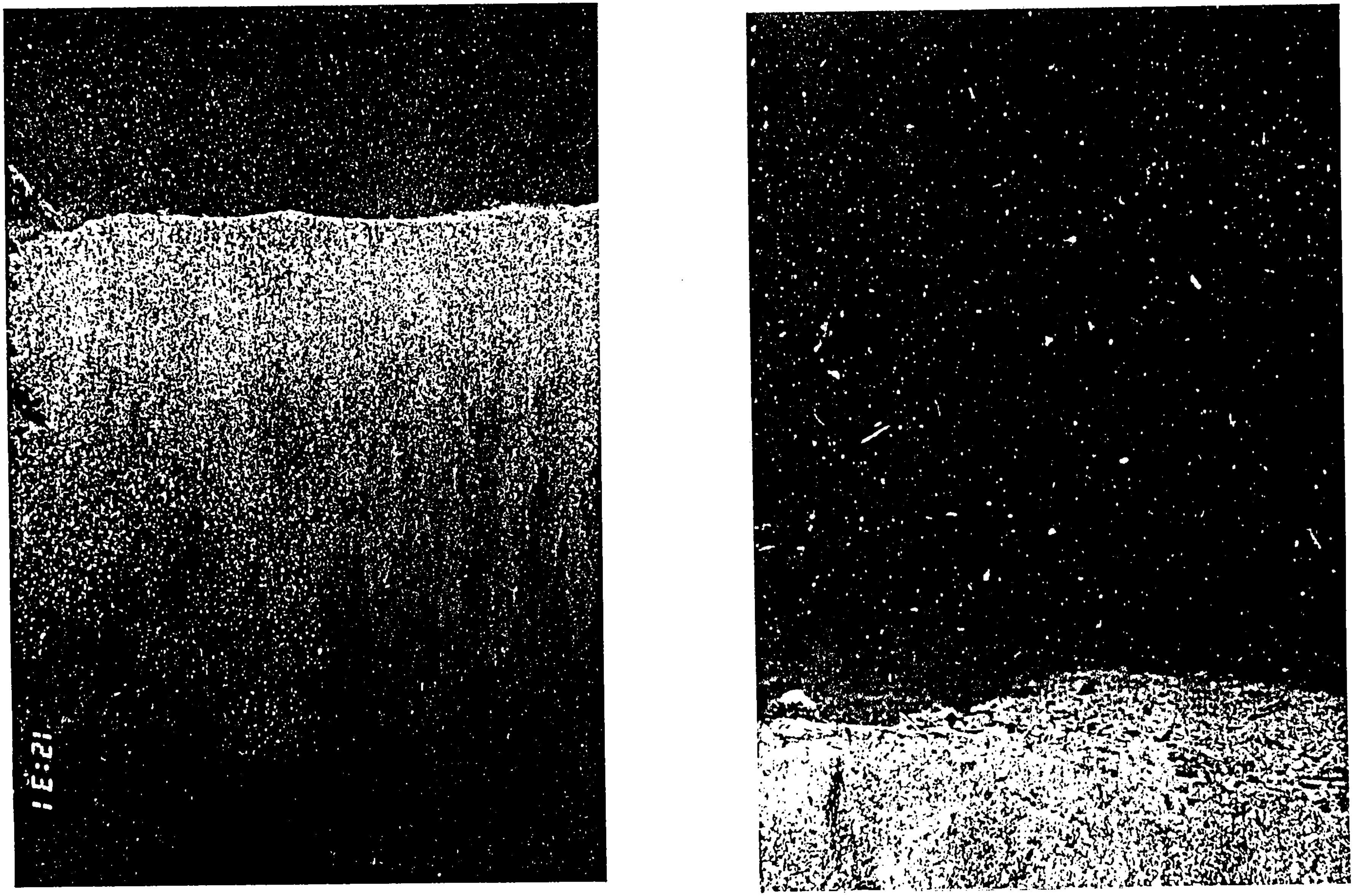

Figure 3-4. REMOTS® images AB7/B (left) and ECA5/B. AB7/B exhibits a layer of sand overlying relatively homogeneous silt/clays. Relict RPD and biogenic structures are seen within the silt/clays. These silt/clays are interpreted as representing native sediments. The overlying sand layer is inferred to be a mixture of fine grained material and capping sands. Note the irregular contact between the silt/clays and the overlying sand layer. Image ECA5/B shows cap sands with invertebrate fecal strings at the sediment water interface along with wood debris at the sediment surface (dark fragments) as well as tube structures.

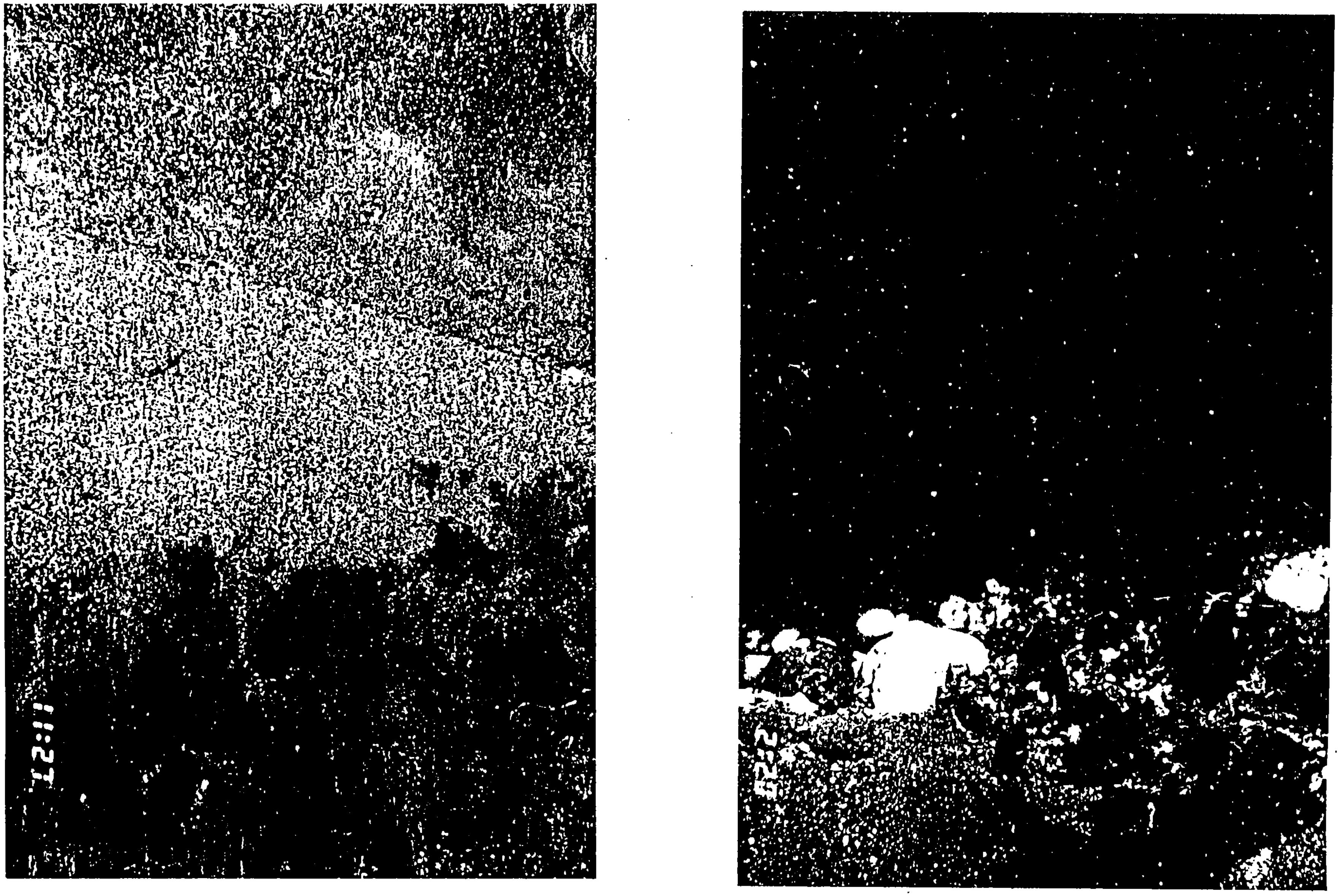

Figure 3-5. REMOTS® images AB1/B (left) and DC0/B. Image AB1/B shows the very edge of the sediment cap with well sorted cap sands overlying black, native muds. The contact between the cap and the native sediments is relatively undisturbed indicating effective isolation of the native material. Note the presence of methane gas bubbles within the native sediments. Image DC0/B shows a dark sandy substratum with scattered rocks, shells and algal growth. Note that an RPD is not present in DC0/B. This material is near the Denny Way CSO and is interpreted to be native.

of reddish granules and the clean (high reflectance) nature of the sands in this layer suggests that the source was cap material. The thickness of the sand layer at these locations varies from two to ten centimeters. These layers are intercalated with a significant amount of fine grained material suggesting periodic resuspension/redeposition or admixing of the sands with finer grained material. The fine grained, gray substrate underlying the sand layer exhibits a relatively homogeneous fabric and is interpreted to be native material. Relict biogenic structures may be seen in the underlying silt/clays.

Shoreward of the cap boundary, the lateral gradation of cap material to native sediments is more subtle, especially in the area immediately adjacent to the Denny Way CSO. Station AB1 replicate B is shown in Figure 3-5 and exhibits the very edge of the sediment cap. This is the only image where the camera prism penetrated through the cap to show the underlying native sediments. In this image the cap is characterized by nearly unimodal medium to coarse, clean sand overlying highly reduced, low reflectance muds. A striking feature of the native sediments observed at Station AB1/B is the presence of methane bubbles within the sediment column. These are identified by the high index of refraction at the edges of each gas bubble which results in a glassy appearance. The occurrence of methanogenesis within these sediments indicates reducing conditions and high inventories of reactive organic material. Based on the sharp contact between the cap and the underlying native sediments, the cap is effective at physically covering the underlying material. It is unknown if the ebullition of the methane gas through the capping sands is capable of transferring native sediments upward through the cap.

Elsewhere shoreward of the cap boundary (eg. Stations DC0, two of three replicates, and S), the native sediments do not appear to be capped. These sediments are medium to fine grained sands. A distinguishing characteristic of these native sands is their low reflectance at the sediment-water interface as well as at depth within the sediment column. These sediment apparently have high sulfide inventories. The sediment profile image from Station DC0/B is shown in Figure 3-5. Scattered pieces of sea lettuce and fronds of bull kelp upon the sediment surface are frequently observed at the stations inboard of the cap. Stations DC0 and S are immediately adjacent to a kelp bed of *Macrocystis* which is located inboard of the eastern-most edge of the cap boundary. Kelp fronds may be transported to these stations from the kelp bed. This kelp bed was also present prior to cap emplacement.

Figure 3-6 shows the distribution of prism penetration depth measured across the capping area. Providing the amount of lead in the adjustable weight packs remains constant, the depth of prism penetration is a relative measure of sediment shear strength. Throughout the survey, excepting Stations AB7 and DC7, the amount of weight in the camera was 200 pounds (100 per weight pack). The sediment shear strength is a function of grain size, state of compaction and pore water content. Generally, the prism penetration

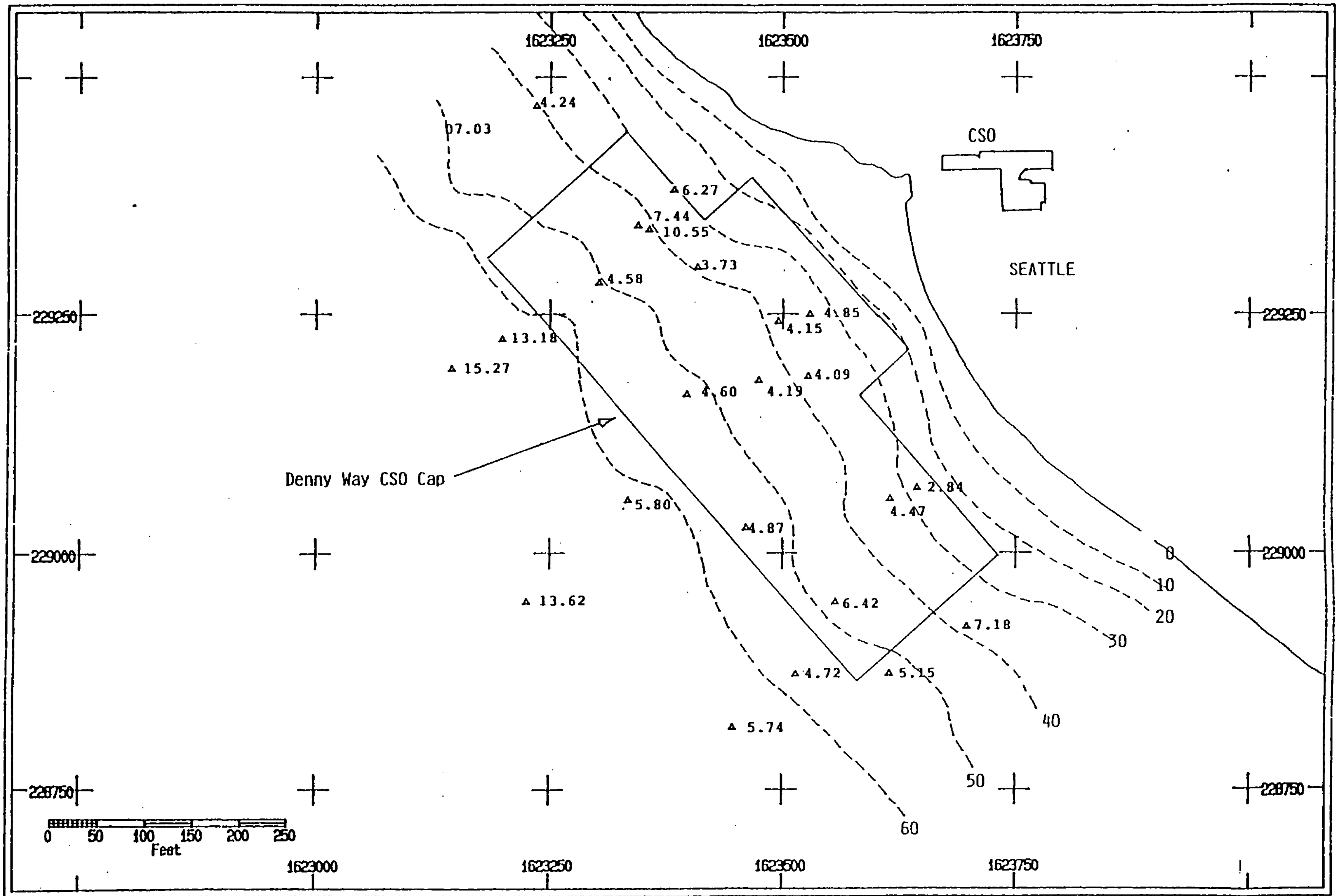

Figure 3-6. The distribution of camera prism penetration depths observed at the Denny Way CSO cap. All penetration measures are in centimeters. Water depths are in feet (MLLW).

depths increase seaward of the cap. With the exception of Station AB1/B, prism penetration did not exceed cap thickness, even with highly loaded weight packs. The coarse nature of the cap sands inhibited deep prism penetration. Stations AB7, FE7 and FDB7, exhibited markedly greater prism penetration depths due to the low shear strength of the native silt/clays even though the native sediments were overlain by a thin (10 cm or less) layer of cap sands.

The small scale boundary roughness values range from 0.04 to 1.78 centimeters with 70 percent of the BR values ranging between 0.5 and 1.5 cm. These are modest values. When boundary roughness features are biogenic in origin, ie. due to predation or feeding structures, the boundary roughness values may be on the order of several centimeters. The BR features observed from the images within and adjacent to sediment cap boundary are a mix of physically and biogenically induced structures. Many of the boundary roughness features of physical origin are bedforms (ie. ripples). Figure 3-3, image DC3/C, exhibits a bedform of well sorted sand. The presence of bedforms indicates movement of material along the seafloor due to either waves or other currents. The distribution of image analysis derived apparent redox potential discontinuity (RPD) depths is presented in Figure 3-7. The apparent RPD is discerned as the transition from tan, oxidized sediments to underlying grey to black, reduced sediments. The images acquired from the Denny Way cap show both pronounced and subtle RPD contrasts. Subtle RPD contrasts, from tan to light grey, suggest that the underlying sediments do not have high sulphide inventories (ie. are not organically overloaded) whereas high contrast RPDs, from tan to black, are indicative of high organic content. The depth of the apparent RPD generally indicates the depth of rapid bioturbation. From Figure 3-7, apparent RPD depths increase with distance from the shoreline. The depth of prism penetration also increases with distance from the shore. Stations inboard of the cap do not exhibit an apparent RPD. These stations inboard of the cap exhibit low reflectance sands without an overlying tan, oxidized layer. This lack of an RPD is most likely due to a high sediment oxygen demand caused by organic loading. Possible inputs of reactive organic material to stations inboard of the cap boundary are the Denny Way CSO and abundant aquatic vegetation from the nearby kelp bed or macroalgae (macroalgae was observed in the majority of replicate images take at the inboard stations).

3.2 Biological Features and the Organism-Sediment Index

The distribution of infaunal successional stages is presented in Figure 3-8. The Denny Way CSO Cap area is dominated by Stage I seres. Near the cap fringe and offshore of the cap boundary, stage II taxa are present. Stage I taxa are among the first species of benthic infauna to colonize an area after a disturbance. Stage I organisms typically live at the sediment water interface and forage on suspended or recently deposited detritus. Stage I assemblages typically include worms from the polychaete families *Spionidae*,

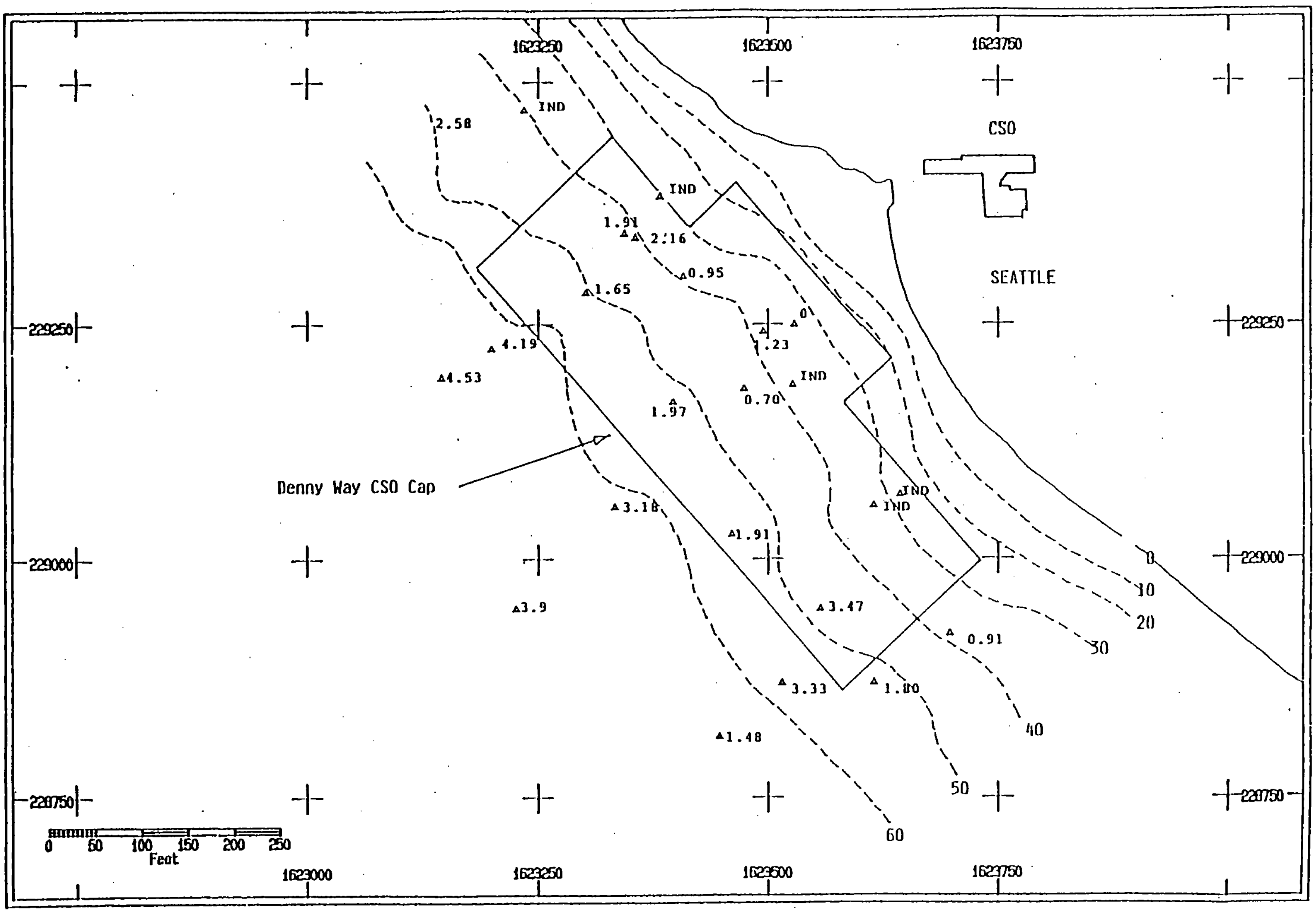

Figure 3-7. The distribution of apparent RPD depths measured at the Denny Way CSO cap. RPD depths are measured in centimeters. Water depths are in feet (MLLW).

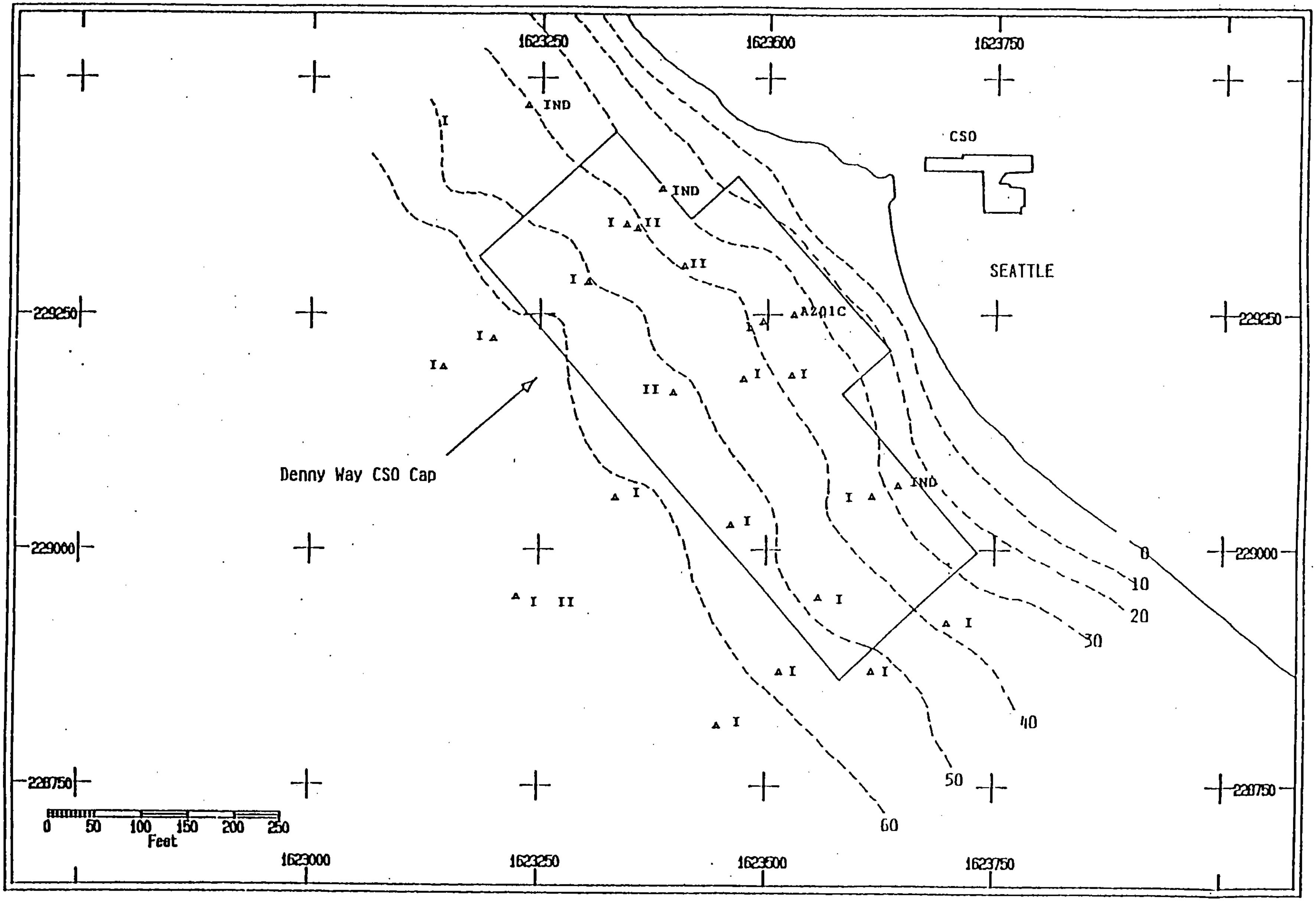

Figure 3-8. The distribution of infaunal successional stages observed at the Denny Way CSO cap. Successional stage designations are unitless. Water depths are in feet (MLLW).

Capitellidae, and *Oweniidae* as well as the class *Oligochaeta* (Rhoads and Germano, 1986). They may use the substrate to construct tubes, but they are typically suspension or surface deposit feeders and do not acquire nutrition from ingestion of deep sediments. Stage II taxa are intermediary between stage I and deposit feeding stage III taxa. Characteristic stage II organisms are tubicolous amphipods and shallow dwelling, surface deposit feeding bivalves such as *Macoma*. There is no evidence of stage III taxa at and adjacent to the Denny Way CSO cap based on REMOTS® images. The presence of stage III organisms is inferred from the identification of feeding voids at depth. If Stage III fauna are present at the Denny Way Cap, the feeding voids would have been deeper in the sediment column than the prism penetration depth.

The distribution of organism-sediment indices (OSIs) for analyzed imaged is presented in figure 3-9. The OSI is a summary parameter that can indicate benthic habitat quality. The OSI is calculated using the depth of the apparent RPD, the infaunal successional stage, the presence of sedimentary methane and the presence of low dissolved oxygen conditions (see Table 2-2). Highest OSI values are found at stations beyond and adjacent to the seaward cap boundary. Stations AB6, AB7, DC6 and DC7 exhibit the highest OSI and are all located beyond the cap boundary. Stations AB6 and DC6 are composed solely of cap sands while AB7 and DC7 exhibit cap sands overlying native silt clays. These stations also exhibit the deepest apparent RPDs. Station DC1 had an OSI of -7, which was the lowest measured and is attributed to the azoic nature of the sediments as well as the presence of low dissolved oxygen conditions at the sediment surface. Low dissolved oxygen conditions are evidenced by the complete absence of oxidized sediments in DC1/C. As this station is near the Denny Way CSO and marine vegetation is abundant in nearby areas, there are likely inputs of labile organic material which, once settled, results in a high sediment oxygen demand. The low OSI's on the sediment cap reflect the recent physical impact by deposition of capping sands whereas at stations seaward of the cap, the OSI's are higher due to thinner deposits of cap material resulting in relatively lesser impacts on resident benthos.

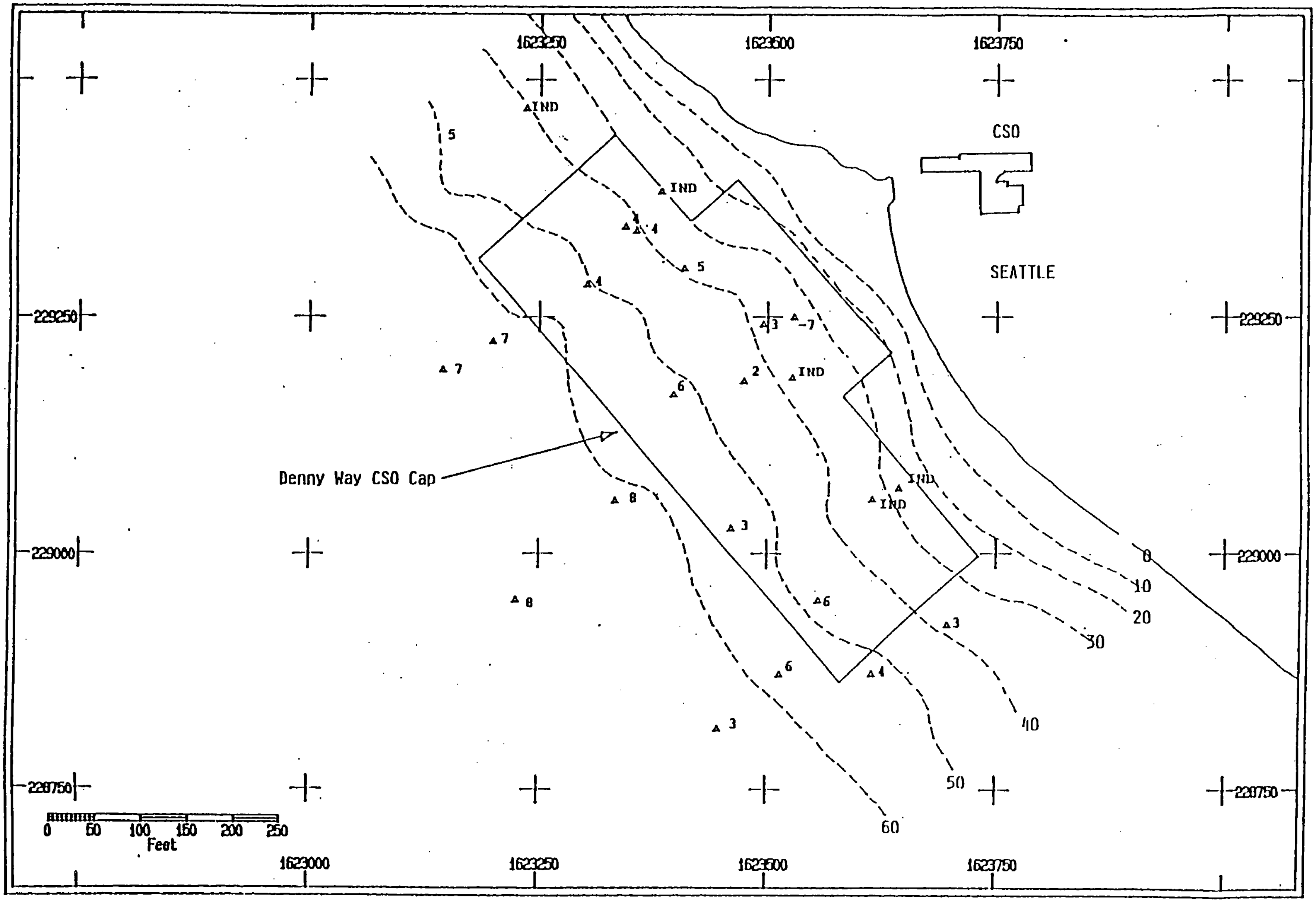

Figure 3-9. The distribution of organism-sediment indices determined from the Denny Way CSO cap. OSI's are unitless values. Water depths are in feet (MLLW).

4.0 DISCUSSION

4.1 REMOTS® Results

The two primary objectives of the REMOTS® survey at the Denny Way CSO cap were to map the extent of cap material and to document the extent and magnitude of cap colonization. Cap sediments were observed at all stations except ECA8, DC0 and S (capping sands were observed from one of three DC0 replicate images). At these stations, capping material may be present but cannot be positively identified from the REMOTS® images. At ECA8, north of the cap, a thin layer (1 to 2 cm) of sand overlies native, gray silt/clays. This sand layer does not exhibit diagnostic features attributed to the sands used for capping whereas at stations DC0 and S, the substrate observed is composed of sands which do not have an apparent RPD. The character of the sands comprising the cap varies from station to station and between replicates within a station. With the exception of Station AB1 replicate B, penetration of the camera prism was always less than the thickness of the cap. No vertical mixing of native and overlying cap materials was observed, even when the camera prism penetrated through to the native sediments.

Capping sands are present beyond the target cap boundaries. Extension of these capping sands beyond the cap boundary may have taken place by deposition/dispersion during cap emplacement, or migration of the cap material after cap emplacement. There is no data documenting the lateral extent of the cap immediately after emplacement. The sediment profile imaging survey was conducted 19 months after cap placement which precludes identifying sands which are solely related to dispersion during cap emplacement. Five bargeloads of capping sands were deposited at the seaward edge of the cap boundary (P. Romberg, pers. comm.). Current ripples were observed at stations within the cap boundary. These bedforms indicate bedload transport, however the direction and magnitude of transport cannot be determined. Many images also show a distinct thin layer of well sorted sands at the surface overlying more poorly sorted cap material. This thin layer may reflect sediment which is periodically mobile and washed of finer grained material. This washed surface deposit appears to armor the underlying material and we expect the armoring process to continue.

The capping material observed at Stations AB7 and DC7, 110 and 210 feet from the seaward edge of the target cap boundary respectively, is a sand-rich layer overlying native sediments. These sand grains are admixed with finer grained sediment. These stations also exhibit the deepest RPDs and greatest prism penetration depths. Based on these observations, it appears that the sands were not deposited over the native muds in a single, depositional event. The sands in this layer may have been introduced along with fine grained material dispersed during cap placement or alternatively as periodic influxes of sand due to bedload transport. These sands may have been subsequently mixed with fine grained material through bioturbation.

The biological conditions existing within the capping sands and ambient bottom at the time of the sediment profile survey (19 months after cap placement) are similar to other disposal sites mapped using REMOTS® (Rhoads and Germano, 1982; SAIC, 1986c; SAIC, 1986d). Stations within the cap boundary as well as beyond exhibit stage I and stage II seres. The stage I fauna are typically opportunistic species and represent the earliest colonizers of disturbed areas (Rhoads et. al., 1978, Rhoads and Germano, 1982). The stage II assemblage represents the start of the infaunalization process. As the cap is relatively thick and emplacement occurred over a short period of time, the mode of colonization of the cap is inferred to be by juvenile recruitment. The critical depth of burial for most estuarine organisms is between 10 and 30 cm (Nichols et. al, 1978; Kranz, 1974; Maurer et. al., 1978). Rapid emplacement of a sediment overburden exceeding 30 cm in thickness appears to cause high burial mortality. It is doubtful that the vertical migration of infauna resident prior to cap emplacement could overcome the rapid deposition, particularly when the physical difference between the native material and capping sediments is considered. However, at stations fringing the cap where the sand layer overlying the native substrate is thin (eg. <30 cm), vertical migration of resident infauna may have taken place at these few sites (AB7, DC7, FE7). These stations also exhibit the highest OSIs and deepest RPDs. Recolonization of a physically disturbed area by stage I infauna occurs over a relatively short time scale ie. day to months (Rhoads et. al., 1978; Rhoads and Germano, 1982). In contrast, the colonization of stage III organisms by juvenile recruitment typically takes months to years (Germano and Rhoads, 1984).

4.2 Correlation of REMOTS® with Videotape Surveys and Benthic Infaunal Data

Video surveys by diver held videocamera were conducted immediately after cap emplacement in 1990 as well as one year later in 1991. Sediment samples for benthic infaunal analysis were also collected in 1990 and 1991. The videos were taken of transects marked by stakes. These transects spanned from stakes D to C (REMOTS® DC4 to DC2), C to A (DC2 to AB2) and A to B (AB2 to AB4) with each transect being approximately 100 feet in length. The same transects were occupied during both years of the video survey. The samples for benthic taxonomy were taken at two stations J and M which are most closely approximated in location by REMOTS® stations AB3 and FE3 respectively. The locations of the diver-held video camera survey and benthic taxonomy stations J and M are presented in Figure 4-1.

The 1990 video shows a cap surface immediately after cap placement. The surface is relatively flat with clasts of cohesive muds and woody material standing in relief above the surface. It appears that during

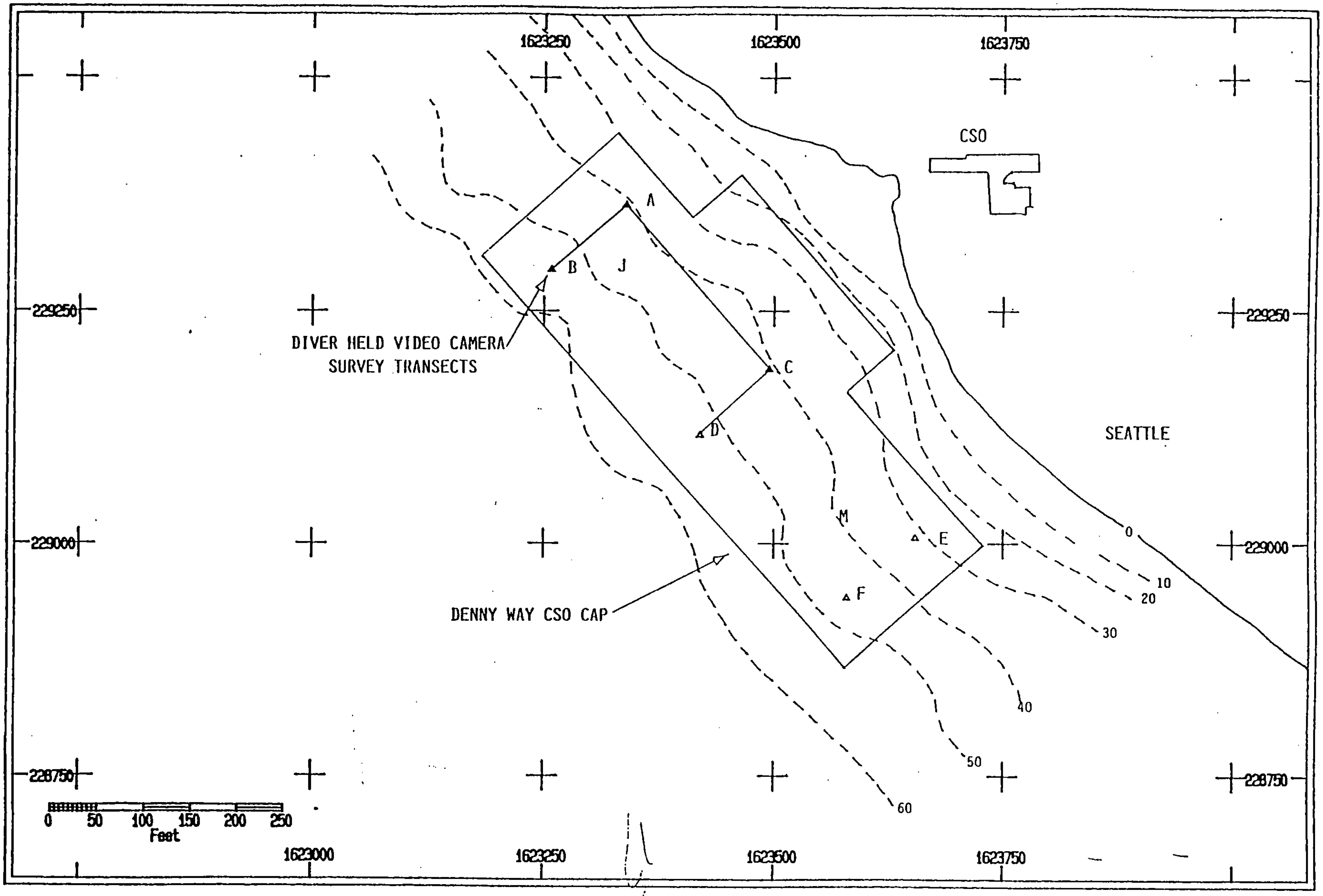

Figure 4-1. The locations of the diver held video camera survey transects as well as benthic taxonomy station J and M.

emplacement, the sandy capping material spread out laterally to form a blanket deposit. In this early 1990 video survey there is no evidence of bottom scour or bedload transport as ripples were absent and a thin veneer of fine grained, floccular material covers the surface in many places. The resolution of the video, approximately 5 mm, did not allow the detection of macrofaunal colonization. Some predators, crabs and flounder, were encountered during the survey, but were not present in great abundance. These predators are mobile and their presence is not necessarily related to their feeding activities on the cap invertebrate community. Many mobile organisms scavenge recently deposited dredged material.

During the 1991 video survey, the surface of the cap is coated with a thin veneer of floccular material in many places. This veneer appears to have a greater proportion of organically bound material than that observed in 1990. Many burrows, tubes and epizoans are also evident during the 1991 survey. In addition to the increased evidence of burrowing and surface dwelling macrofauna, pieces of marine vegetation and fronds of kelp can be seen littering the sediment surface. The exudates from this decaying vegetation as well as the detritus itself can directly serve as a source of nutrition for the macrobenthos. The flocculent material, when introduced into suspension by the diver, appears to be larger during 1991 than in the 1990 video. This may be related to the binding of detritus by macrofauna during burrow or tube construction, fecal pellets and/or algal mucus films. Many of these floccular biogenic aggregates are also seen in suspension in the REMOTS® images. However, the surficial floccular deposit was observed to be patchy during the REMOTS® survey. More predators and surface scavengers were observed during the 1991 video survey than were observed during 1990.

Sediment samples for benthic infauna were collected from Stations J and M (located on the cap) during both 1990 and 1991. The benthic taxonomy data can be related to the REMOTS® results in terms of the successional stages and the appearance of functional types. The sediment profile imagery indicates that the cap area is dominated by a stage I community which is transitioning to stage II. For pooled replicates in 1990, the faunal composition consists mainly of juvenile bivalves (*Macoma*), the gastropod *Alvania compacta* and the near surface feeding polychaetes *Capitella capitata* (*Capitellidae*), *Prionspio steensrupi* (*Spionidae*) and *Aphelochaeta multifilis* (*Cirratulidae*). Bivalves and crustaceans are conspicuous in their rarity with the exception of *Macoma* and the ostracod *Euphilomedes carcharodonta*. *Spionids* and *Capitellids* are known to be stage I colonizers of disturbed environments such as disposal sites as well as naturally defaunated sediments. *Macoma* represents an early stage II colonizer although those observed during the 1990 surveys were juveniles. The benthic data indicate a typical stage I community. Stage III taxa are rare in the 1990 samples and are represented by the polychaete worms *Pectinaria californiensis* and *Pectinaria granulata*.

The 1991 benthic data indicate that species richness increased since the 1990 sampling as evidenced by the increase in number of species in each taxonomic group observed in 1991 samples relative to 1990 samples. Stage one fauna still numerically dominate in 1991. The 1991 numerical dominants for pooled replicates from Stations J and M consist of the ostracod *Euphilomedes carcharodonta* (*Philomedidae*), the polychaetes *Lumbrineris* (*sp. ind.*; *Lumbrineridae*), *Capitella capitata* (*Capitellidae*), *Aphelochaeta multifilis* (*Cirratulidae*), *Prionspio steensrupi* (*Spionidae*) and *Heteromastus filibranchus* (*Capitellidae*). The bivalve *Axinopsida serricata* was the only mollusc in the top ten numerically dominant species from both Stations J and M. Juvenile *Macoma* were eighth among the top ten dominants at Station M during 1991. A stage I community is still present at these stations during 1991. As in 1990, the stage III polychaete family *Pectinariidae* is present in sparse numbers although in greater abundance than observed during 1990. The Stage III polychaete families *Maldanidae* and *Ampharetidae* are present in small numbers in 1991 samples while absent in 1990 samples. In addition, the *Orbiniid* polychaete, *Leitoscoloplus pugettensis* is the tenth numerically dominant organism at both stations during 1991. This indicates that the cap is still largely in a stage I condition but progressing slowly and patchily to a stage II or II to III community. If no further disturbance takes place, one may expect the cap to converge with the ambient bottom over time.

Biomass data from the 1990 and 1991 samples indicate a weight increase in all taxonomic groups at both stations during 1991. The total biomass for polychaetes, crustaceans and molluscs increased in 1991. At both Stations J and M during 1990, polychaetes represented 73 and 74% of the total biomass as averaged across all replicates whereas in 1991 polychaetes represented 54 and 51 percent of the total biomass respectively. The proportional increase in crustacean biomass at Station M in 1991 was dramatic and is caused by high abundance in one replicate. It should be noted that while the numbers of individuals for the molluscs *Macoma sp.* and *Alvania compacta* were dramatically reduced during 1991, the molluscan biomass increased during the same time span.

The higher densities of predators, flounder, starfish and crabs, observed in the 1991 video survey may be coupled to the higher densities and biomass of their invertebrate prey. During the period of rapid recruitment of stage I and II infauna, disposal sites are known to attract demersal predators because of the high secondary production associated with the colonization process (Rhoads et. al., 1978; SAIC, 1987).

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APPENDIX A

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 1120        Date . . . . . 102391
Number  . . . . ab1        Frame  . . 1           Initials . . . FCE
Replicate . . . a          Roll . . . 1           Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  6.95 cm   Boundary roughness . .  1.36 cm.
  Minimum . . . .  5.59 cm   Roughness type . . . .  Physical
  Average . . . .  6.27 cm
-----------------------------------------------------------------------
RAIN SIZE
  Mode . . .    1 to 2 phi   Range . . . . .    0 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . . Indet      Width . . . Indet
  Maximum . . . . Indet      Area  . . . Indet
  Average . . . . Indet
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
-----------------------------------------------------------------------
UD CLASTS
  Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
-----------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm   Number  . .  0
  Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
DREDGED MATERIAL
  Depth . . . . .  6.95 cm
-----------------------------------------------------------------------
COMMENTS
  Form comments:
  -0                -DM > Pen          -Low Pen          -0
  -0                -0                 -0                -0
  -0                -0                 -0                -0
  -0                -0                 -0                -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
     x
-----------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . INDET
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . Indeterminate
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 1141       Date . . . . . 102391
Number . . . . ab2         Frame  . . 1          Initials . . . FCE
Replicate . . . a          Roll . . . 1          Plan view  . . NO
---------------------------------------------------------------------
ENETRATION
   Maximum . . . . 11.06 cm   Boundary roughness . .  1.02 cm
   Minimum . . . . 10.04 cm   Roughness type . . . .  Physical
   Average . . . . 10.55 cm
---------------------------------------------------------------------
RAIN SIZE
   Mode . . .  3 to 4 phi   Range . . . . . 2 to > 4 phi
---------------------------------------------------------------------
PPARENT RPD
   Minimum . . . .  1.23 cm   Width . . . 13.77 cm
   Maximum . . . .  3.09 cm   Area  . . . 29.76 cm2
   Average . . . .  2.16 cm
---------------------------------------------------------------------
EDOX REBOUND LAYER
   Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
---------------------------------------------------------------------
UD CLASTS
   Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
---------------------------------------------------------------------
ETHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
---------------------------------------------------------------------
DREDGED MATERIAL
   Depth . . . . . 11.06 cm
---------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                -DM > Pen          -0                  -0
   -Sand/Mud         -0                 -0                  -0
   -0                -0                 -0                  -0
   -0                -0                 -0                  -0

   Add measure . .  0.79 cm   Comment: sand layer thickness

   General comment:
     f: sand over vf sand, ripped up tube mat
---------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage II ON Stage III
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 8
=====================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 1153        Date . . . . . 102391
Number  . . . . ab3        Frame  . . 1           Initials . . . FCE
Replicate . . . c          Roll . . . 1           Plan view  . . NO
------------------------------------------------------------------------
NETRATION
Maximum . . . . . 8.22 cm  Boundary roughness . .  1.57 cm
Minimum . . . .  6.65 cm   Roughness type . . . .  Physical
Average . . . .  7.44 cm
------------------------------------------------------------------------
AIN SIZE
Mode . . .   2 to 3 phi    Range . . . . .  2 to > 4 phi
------------------------------------------------------------------------
PARENT RPD
Minimum . . . .  1.19 cm   Width . . . 13.64 cm
Maximum . . . .  2.63 cm   Area  . . . 26.01 cm2
Average . . . .  1.91 cm
------------------------------------------------------------------------
EDOX REBOUND LAYER
Top . . . . . .  0.00 cm   Bottom . .  0.00 cm   Width  . .  0.00 cm
------------------------------------------------------------------------
JD CLASTS
Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
------------------------------------------------------------------------
ETHANE
Minimum . . . .  0.00 cm   Number  . .  0
Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
Average . . . .  0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
Depth . . . . .  8.22 cm
------------------------------------------------------------------------
OMMENTS
Form comments:
-0                  -DM > Pen           -0                  -0
-0                  -0                  -0                  -0
-0                  -0                  -0                  -0
-0                  -0                  -0                  -0

Add measure . .  0.51 cm   Comment: sand thickness

General comment:
    fe2o3 being deposited in situ near or above redox
------------------------------------------------------------------------
IOLOGICAL
Successional stage . . . . . . Stage I
Low DO present . . . . . . . . NO
Organism Sediment Index  . . 4
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay     Time . . . 1157      Date . . . . . 102391
Number  . . . . ab4       Frame  . . 1         Initials . . . FCE
Replicate . . . a         Roll . . . 1         Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
   Maximum . . . .  4.91 cm   Boundary roughness . .  0.68 cm
   Minimum . . . .  4.24 cm   Roughness type . . . .  Physical
   Average . . . .  4.58 cm
-----------------------------------------------------------------------
RAIN SIZE
   Mode . . .    2 to 3 phi   Range . . . . . .   2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
   Minimum . . . .  1.14 cm   Width . . . 13.77 cm
   Maximum . . . .  2.16 cm   Area  . . . 22.75 cm2
   Average . . . .  1.65 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
   Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
-----------------------------------------------------------------------
UD CLASTS
   Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
-----------------------------------------------------------------------
ETHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
-----------------------------------------------------------------------
REDGED MATERIAL
   Depth . . . . .  4.91 cm
-----------------------------------------------------------------------
OMMENTS
    Form comments:
    -0                -DM > Pen          -0                -0
    -0                -0                 -0                -0
    -0                -0                 -0                -0
    -0                -0                 -0                -0

    Add measure . .  0.00 cm   Comment: x

    General comment:
        iron oxide coated tubes, plant? fragments
-----------------------------------------------------------------------
BIOLOGICAL
    Successional stage . . . . . Stage I
    Low DO present . . . . . . . NO
    Organism Sediment Index  . . 4
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 1214       Date . . . . . 102391
Number  . . . . ab6        Frame  . . 1          Initials . . . FCE
Replicate . . . b.         Roll . . . 1          Plan view  . . NO
------------------------------------------------------------------------
NETRATION
 Maximum . . . . 14.07 cm  Boundary roughness . .  1.78 cm
 Minimum . . . . 12.29 cm  Roughness type . . . .  Physical
 Average . . . . 13.18 cm
------------------------------------------------------------------------
AIN SIZE
 Mode . . .    2 to 3 phi  Range . . . . .    2 to 4 phi
------------------------------------------------------------------------
PARENT RPD
 Minimum . . . .  2.80 cm  Width . . . 13.73 cm
 Maximum . . . .  5.59 cm  Area  . . . 57.58 cm2
 Average . . . .  4.19 cm
------------------------------------------------------------------------
DOX REBOUND LAYER
 Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm  Width  . .  0.00 cm
------------------------------------------------------------------------
JD CLASTS
 Number . . . .   0        Size  . . .  0.00 cm  Status . .  x
------------------------------------------------------------------------
ETHANE
 Minimum . . . .  0.00 cm  Number  . .  0
 Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
 Average . . . .  0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
 Depth . . . . . 14.07 cm
------------------------------------------------------------------------
OMMENTS
 Form comments:
 -0                -DM > Pen         -0                -0
 -0                -0                -0                -0
 -0                -0                -0                -0
 -0                -0                -0                -0

 Add measure . .  0.00 cm   Comment: x

 General comment:
     gas escape chambers, tubes at depth
------------------------------------------------------------------------
IOLOGICAL
 Successional stage . . . . . Stage I
 Low DO present . . . . . . . NO
 Organism Sediment Index  . . 7
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay    Time . . . 1229       Date . . . . . . 102391
Number  . . . . ab7      Frame  . . 1          Initials . . . FCE
Replicate . . . a        Roll . . . 1          Plan view  . . NO
----------------------------------------------------------------------
PENETRATION
   Maximum . . . . 15.68 cm   Boundary roughness . .  0.81 cm
   Minimum . . . . 14.87 cm   Roughness type . . . .  Physical
   Average . . . . 15.27 cm
----------------------------------------------------------------------
GRAIN SIZE
   Mode . . .    2 to 3 phi   Range . . . . .  2 to > 4 phi
----------------------------------------------------------------------
APPARENT RPD
   Minimum . . . .  3.69 cm   Width . . . 13.81 cm
   Maximum . . . .  5.38 cm   Area  . . . 62.62 cm2
   Average . . . .  4.53 cm
----------------------------------------------------------------------
REDOX REBOUND LAYER
   Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width . . .  0.00 cm
----------------------------------------------------------------------
MUD CLASTS
   Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
----------------------------------------------------------------------
METHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
----------------------------------------------------------------------
DREDGED MATERIAL
   Depth . . . . . 15.68 cm
----------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                -DM > Pen          -0             -0
   -Sand/Mud         -0                 -0             -0
   -Poor Sort        -0                 -0             -0
   -0                -0                 -0             -0

   Add measure . .  6.31 cm   Comment: depth to sand layer

   General comment:
       s/m surface erosion
----------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage I
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 7
======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay     Time . . . 0215      Date . . . . . 102391
Number  . . . . dc1       Frame  . . 1         Initials . . . FCE
Replicate . . . c         Roll . . . 1         Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  5.21 cm  Boundary roughness . .  0.72 cm.
  Minimum . . . .  4.49 cm  Roughness type . . . .  Physical
  Average . . . .  4.85 cm
-----------------------------------------------------------------------
RAIN SIZE
  Mode . . .    2 to 3 phi  Range . . . . .    2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  0.00 cm  Width . . .  0.00 cm
  Maximum . . . .  0.00 cm  Area  . . .  0.00 cm2
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm  Width  . .  0.00 cm
-----------------------------------------------------------------------
UD CLASTS
  Number  . . . .  0        Size  . . .  0.00 cm  Status . .  x
-----------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm  Number  . .  0
  Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . .  5.21 cm
-----------------------------------------------------------------------
OMMENTS
  Form comments:
  -0                -DM > Pen          -0                 -0
  -0                -0                 -0                 -0
  -0                -0                 -0                 -0
  -0                -0                 -0                 -0

  Add measure . .  0.00 cm  Comment: x

  General comment:
      plants and shells on surface
-----------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . AZOIC
  Low DO present . . . . . . . YES
  Organism Sediment Index  . . -7
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay       Time . . . 0207        Date . . . . . 102391
Number  . . . . dc2         Frame  . . 1           Initials . . . FCE
Replicate . . . a           Roll . . . 1           Plan view  . . NO
--------------------------------------------------------------------------
PENETRATION
   Maximum . . . .  4.36 cm   Boundary roughness . .  0.42 cm
   Minimum . . . .  3.94 cm   Roughness type . . . .  Physical
   Average . . . .  4.15 cm
--------------------------------------------------------------------------
GRAIN SIZE
   Mode . . .   1 to 2 phi  Range . . . . .    2 to 3 phi
--------------------------------------------------------------------------
APPARENT RPD
   Minimum . . . .  1.19 cm   Width . . . 13.73 cm
   Maximum . . . .  1.27 cm   Area  . . . 16.87 cm2
   Average . . . .  1.23 cm
--------------------------------------------------------------------------
REDOX REBOUND LAYER
   Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
--------------------------------------------------------------------------
MUD CLASTS
   Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
--------------------------------------------------------------------------
METHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
--------------------------------------------------------------------------
DREDGED MATERIAL
   Depth . . . . .  4.36 cm
--------------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                 -DM > Pen          -0                 -0
   -0                 -0                 -0                 -0
   -0                 -0                 -0                 -0
   -0                 -0                 -0                 -0

   Add measure . .  0.00 cm   Comment: x

   General comment:
       iron oxide being deposited in situ above redox
--------------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage I
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 3
==========================================================================
```

SAIC REMOTS DATASHEET

```
   Station . . . . elbay      Time . . . 0204        Date . . . . . 102391
   Number  . . . . dc3        Frame  . . 1           Initials . . . FCE
   Replicate . . . c          Roll . . . 1           Plan view  . . NO
------------------------------------------------------------------------
ENETRATION
   Maximum . . . .  5.04 cm   Boundary roughness . .  1.69 cm
   Minimum . . . .  3.35 cm   Roughness type . . . .  Physical
   Average . . . .  4.19 cm
------------------------------------------------------------------------
RAIN SIZE
   Mode . . .    2 to 3 phi   Range . . . . .    2 to 3 phi
------------------------------------------------------------------------
PPARENT RPD
   Minimum . . . .  0.55 cm   Width . . . 13.77 cm
   Maximum . . . .  0.85 cm   Area  . . .  9.63 cm2
   Average . . . .  0.70 cm
------------------------------------------------------------------------
EDOX REBOUND LAYER
   Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
------------------------------------------------------------------------
UD CLASTS
   Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
------------------------------------------------------------------------
ETHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
   Depth . . . . .  5.04 cm
------------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                  -DM > Pen          -0                   -0
   -0                  -Bed Forms         -0                   -0
   -0                  -0                 -0                   -0
   -0                  -0                 -0                   -0

   Add measure . .  0.00 cm   Comment: x

   General comment:
     iron oxide being deposited in situ above redox, active bedload transport
------------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage I
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 2
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0157       Date . . . . . 102391
Number  . . . . dc4        Frame  . . 1          Initials . . . FCE
Replicate . . . c          Roll . . . 1          Plan view  . . NO
----------------------------------------------------------------------
ENETRATION
   Maximum . . . .  4.96 cm  Boundary roughness . .  0.72 cm
   Minimum . . . .  4.24 cm  Roughness type . . . .  Physical
   Average . . . .  4.60 cm
----------------------------------------------------------------------
RAIN SIZE
   Mode . . .    2 to 3 phi  Range . . . . .  2 to > 4 phi
----------------------------------------------------------------------
PPARENT RPD
   Minimum . . . .  1.40 cm  Width . . . 13.77 cm
   Maximum . . . .  2.54 cm  Area  . . . 27.13 cm2
   Average . . . .  1.97 cm
----------------------------------------------------------------------
EDOX REBOUND LAYER
   Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm  Width  . .  0.00 cm
----------------------------------------------------------------------
IUD CLASTS
   Number  . . . .  0        Size  . . .  0.00 cm  Status . .  x
----------------------------------------------------------------------
IETHANE
   Minimum . . . .  0.00 cm  Number  . .  0
   Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
   Average . . . .  0.00 cm
----------------------------------------------------------------------
REDGED MATERIAL
   Depth . . . . .  4.96 cm
----------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                 -DM > Pen          -Low Pen          -0
   -Sand/Mud          -0                 -0                -0
   -0                 -0                 -0                -0
   -0                 -0                 -0                -0

   Add measure . .  1.24 cm  Comment: sand layer thickness

   General comment:
       ripped up tube mat
----------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage II
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 6
======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0140        Date . . . . . 102391
Number  . . . . dc6        Frame  . . 1           Initials . . . FCE
Replicate . . . c          Roll . . . 1           Plan view  . . NO
-----------------------------------------------------------------------
NETRATION
  Maximum . . . .  6.23 cm  Boundary roughness . .  0.85 cm
  Minimum . . . .  5.38 cm  Roughness type . . . .  Physical
  Average . . . .  5.80 cm
-----------------------------------------------------------------------
AIN SIZE
  Mode . . .    2 to 3 phi  Range . . . . .    2 to 4 phi
-----------------------------------------------------------------------
PARENT RPD
  Minimum . . . .  2.37 cm  Width . . . 13.81 cm
  Maximum . . . .  3.98 cm  Area  . . . 43.89 cm2
  Average . . . .  3.18 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm  Width  . .  0.00 cm
-----------------------------------------------------------------------
JD CLASTS
  Number  . . . .  0        Size  . . .  0.00 cm  Status . .  x
-----------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm  Number  . .  0
  Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . .  6.23 cm
-----------------------------------------------------------------------
OMMENTS
  Form comments:
  -0                 -DM > Pen          -0                 -0
  -0                 -0                 -0                 -0
  -Poor Sort         -0                 -0                 -0
  -0                 -0                 -0                 -0

  Add measure . .  0.81 cm   Comment: sand thickness on surface

  General comment:
      sand/mud/sand, stage two retrograde
-----------------------------------------------------------------------
IOLOGICAL
  Successional stage . . . . . . Stage II
  Low DO present . . . . . . . . NO
  Organism Sediment Index  . . 8
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0121        Date . . . . . . 102391
Number  . . . . dc7        Frame  . . 1           Initials . . . FCE
Replicate . . . b          Roll . . . 1           Plan view  . . NO
---------------------------------------------------------------------------
ENETRATION
  Maximum . . . . 14.32 cm   Boundary roughness . .  1.40 cm *
  Minimum . . . . 12.92 cm   Roughness type . . . .  Physical
  Average . . . . 13.62 cm
---------------------------------------------------------------------------
RAIN SIZE
  Mode . . .    3 to 4 phi   Range . . . . .  2 to > 4 phi
---------------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  3.56 cm   Width . . . 13.81 cm
  Maximum . . . .  4.24 cm   Area  . . . 53.84 cm2
  Average . . . .  3.90 cm
---------------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
---------------------------------------------------------------------------
UD CLASTS
  Number  . . . .  4          Size  . . .  0.65 cm   Status . .  Oxidized
---------------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm   Number  . .  0
  Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
  Average . . . .  0.00 cm
---------------------------------------------------------------------------
DREDGED MATERIAL
  Depth . . . . . 14.32 cm
---------------------------------------------------------------------------
COMMENTS
   Form comments:
   -0                -DM > Pen        -0              -0
   -Sand/Mud         -0               -0              -0
   -0                -0               -0              -0
   -0                -0               -0              -0

   Add measure. . .  5.22 cm   Comment: sand layer thickness

   General comment:

---------------------------------------------------------------------------
BIOLOGICAL
   Successional stage . . . . . Stage I -> II
   Low DO present . . . . . . . NO
   Organism Sediment Index  . . 8
===========================================================================
```

SAIC REMOTS DATASHEET

Station	elbay	Time . . .	0351	Date	102391
Number	fe2	Frame . .	1	Initials . . .	FCE
Replicate . . .	c	Roll . . .	1	Plan view . .	NO

PENETRATION

Maximum	5.13 cm	Boundary roughness . .	1.31 cm
Minimum	3.81 cm	Roughness type	Physical
Average	4.47 cm		

GRAIN SIZE

Mode . . .	2 to 3 phi	Range	2 to 3 phi

APPARENT RPD

Minimum	Indet	Width . . .	Indet
Maximum	Indet	Area . . .	Indet
Average	Indet		

REDOX REBOUND LAYER

Top	0.00 cm	Bottom . .	0.00 cm	Width . .	0.00 cm

MUD CLASTS

Number	0	Size . . .	0.00 cm	Status . .	x

METHANE

Minimum	0.00 cm	Number . .	0
Maximum	0.00 cm	Size . . .	0.00 cm
Average	0.00 cm		

DREDGED MATERIAL

Depth . . . . . 5.13 cm

COMMENTS

Form comments:

-0	-DM > Pen	-0	-0
-0	-0	-0	-0
-0	-0	-0	-0
-0	-0	-0	-0

Add measure . . 0.00 cm Comment: x

General comment:
plant material on surface?

BIOLOGICAL

Successional stage . . . . . Stage I
Low DO present . . . . NO
Organism Sediment Index . . Indeterminate

SAIC REMOTS DATASHEET

```
Station . . . . elbay    Time . . . 0353       Date . . . . . 102391
Number  . . . . fe1      Frame  . . 1          Initials . . . FCE
Replicate . . . a        Roll . . . 1          Plan view  . . NO
---------------------------------------------------------------------------
ENETRATION
  Maximum . . . .  3.39 cm  Boundary roughness . .  1.10 cm
  Minimum . . . .  2.29 cm  Roughness type . . . .  Physical
  Average . . . .  2.84 cm
---------------------------------------------------------------------------
RAIN SIZE
  Mode . . .   2 to 3 phi   Range . . . . .    2 to 3 phi
---------------------------------------------------------------------------
PPARENT RPD
  Minimum . . . . Indet     Width . . . Indet
  Maximum . . . . Indet     Area  . . . Indet
  Average . . . . Indet
---------------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm  Bottom . . .  0.00 cm   Width  . .  0.00 cm
---------------------------------------------------------------------------
UD CLASTS
  Number  . . . .  0        Size  . . .  0.00 cm   Status . .  x
---------------------------------------------------------------------------
ETHANE
  Minimum . . . . . 0.00 cm  Number  . .  0
  Maximum . . . . . 0.00 cm  Size  . . .  0.00 cm
  Average . . . . . 0.00 cm
---------------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . .  3.39 cm
---------------------------------------------------------------------------
OMMENTS
  Form comments:
  -0                -DM > Pen          -Low Pen          -0
  -0                -0                 -0                -0
  -0                -0                 -0                -0
  -0                -0                 -0                -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
      plant material, stick in sediment
---------------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . INDET
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . Indeterminate
===========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0333        Date . . . . . 102391
Number . . . . fe4         Frame . . 1            Initials . . . FCE
Replicate . . . a          Roll . . . 1           Plan view . . NO
------------------------------------------------------------------------
NETRATION
  Maximum . . . . 6.91 cm  Boundary roughness . . 0.97 cm
  Minimum . . . . 5.93 cm  Roughness type . . . . Physical
  Average . . . . 6.42 cm
------------------------------------------------------------------------
AIN SIZE
  Mode . . .   2 to 3 phi  Range . . . . . .  2 to 4 phi
------------------------------------------------------------------------
PARENT RPD
  Minimum . . . . 2.75 cm  Width . . . 13.73 cm
  Maximum . . . . 4.19 cm  Area  . . . 47.70 cm2
  Average . . . . 3.47 cm
------------------------------------------------------------------------
DOX REBOUND LAYER
  Top . . . . . . 0.00 cm  Bottom . . 0.00 cm  Width . . 0.00 cm
------------------------------------------------------------------------
JD CLASTS
  Number . . . . 0         Size . . . 0.00 cm  Status . . x
------------------------------------------------------------------------
ETHANE
  Minimum . . . . 0.00 cm  Number . . 0
  Maximum . . . . 0.00 cm  Size . . . 0.00 cm
  Average . . . . 0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . . 6.91 cm
------------------------------------------------------------------------
OMMENTS
  Form comments:
  -0              -DM > Pen       -0              -0
  -0              -Bed Forms      -0              -0
  -0              -0              -0              -0
  -0              -0              -Hydroids       -0

  Add measure . . 0.00 cm   Comment: x

  General comment:
     x
------------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . . Stage I
  Low DO present . . . . . . . . NO
  Organism Sediment Index . . 6
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0255       Date . . . . . 102391
Number  . . . . fe6        Frame  . . 1          Initials . . . FCE
Replicate . . . c          Roll . . . 1          Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  5.04 cm  Boundary roughness . .  0.64 cm
  Minimum . . . .  4.41 cm  Roughness type . . . .  Physical
  Average . . . .  4.72 cm
-----------------------------------------------------------------------
RAIN SIZE
  Mode . . .    2 to 3 phi  Range . . . . .    2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  2.37 cm  Width . . . 13.77 cm
  Maximum . . . .  4.28 cm  Area  . . . 45.80 cm2
  Average . . . .  3.33 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm   Width  . .  0.00 cm
-----------------------------------------------------------------------
IUD CLASTS
  Number  . . . .  0        Size  . . .  0.00 cm   Status . .  x
-----------------------------------------------------------------------
IETHANE
  Minimum . . . .  0.00 cm  Number  . .  0
  Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
DREDGED MATERIAL
  Depth . . . . .  5.04 cm
-----------------------------------------------------------------------
COMMENTS
  Form comments:
  -0                 -DM > Pen          -0              -0
  -0                 -0                 -Mud/Sand       -0
  -0                 -0                 -0              -0
  -0                 -0                 -0              -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
     debris on surface
-----------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . Stage I
  Low DO present . . . . . . . NO
  Organism Sediment Index . . . 6
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0248        Date . . . . . 102391
Number  . . . . fe7        Frame . . . 1          Initials . . . FCE
Replicate . . . c          Roll . . . 1           Plan view  . . NO
--------------------------------------------------------------------------
NETRATION
 Maximum . . . .  6.36 cm  Boundary roughness . .  1.23 cm
 Minimum . . . .  5.13 cm  Roughness type . . . .  Physical
 Average . . . .  5.74 cm
--------------------------------------------------------------------------
RAIN SIZE
  Mode . . .    2 to 3 phi   Range . . . . .  3 to > 4 phi
--------------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  1.06 cm   Width . . . 13.81 cm
  Maximum . . . .  1.91 cm   Area  . . . 20.48 cm2
  Average . . . .  1.48 cm
--------------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
--------------------------------------------------------------------------
UD CLASTS
  Number  . . . .  0          Size  . . .  0.00 cm   Status . .  x
--------------------------------------------------------------------------
ETHANE
   Minimum . . . .  0.00 cm   Number  . .  0
   Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
   Average . . . .  0.00 cm
--------------------------------------------------------------------------
DREDGED MATERIAL
   Depth . . . . .  6.36 cm
--------------------------------------------------------------------------
COMMENTS
    Form comments:
    -0               -DM > Pen          -0              -0
    -0               -0                 -0              -0
    -0               -0                 -0              -0
    -0               -0                 -0              -0

    Add measure . .  0.00 cm   Comment: x

    General comment:
       x.
--------------------------------------------------------------------------
BIOLOGICAL
    Successional stage . . . . . . Stage I
    Low DO present . . . . . . . . NO
    Organism Sediment Index  . . 3
==========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0406        Date . . . . . 102391
Number  . . : . ecal       Frame  . . 1           Initials . . . FCE
Replicate . . . a          Roll . . . 1           Plan view  . . NO
------------------------------------------------------------------------
ENETRATION
Maximum . . . .  7.67 cm   Boundary roughness . .  0.97 cm
Minimum . . . .  6.69 cm   Roughness type . . . .  Physical
Average . . . .  7.18 cm
------------------------------------------------------------------------
RAIN SIZE
Mode . . .    1 to 2 phi   Range . . . . .  2 to > 4 phi
------------------------------------------------------------------------
PPARENT RPD
Minimum . . . .  0.42 cm   Width . . . 13.69 cm
Maximum . . . .  1.40 cm   Area  . . . 12.47 cm2
Average . . . .  0.91 cm
------------------------------------------------------------------------
EDOX REBOUND LAYER
Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
------------------------------------------------------------------------
UD CLASTS
Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
------------------------------------------------------------------------
ETHANE
Minimum . . . .  0.00 cm   Number  . .  0
Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
Average . . . .  0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
Depth . . . . .  7.67 cm
------------------------------------------------------------------------
OMMENTS
 Form comments:
 -0                -DM > Pen          -0                -0
 -0                -0                 -0                -0
 -Poor Sort        -0                 -0                -0
 -0                -0                 -0                -0

 Add measure . .  0.00 cm   Comment: x

 General comment:
     mud clasts in sand cap
------------------------------------------------------------------------
BIOLOGICAL
 Successional stage . . . . . . Stage I
 Low DO present . . . . . . . . NO
 Organism Sediment Index  . . 3
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay     Time . . . 0421     Date . . . . . 102391
Number  . . . . eca4      Frame  . . 1        Initials . . . FCE
Replicate . . . a         Roll . . . 1        Plan view  . . NO
------------------------------------------------------------------------
NETRATION
 Maximum . . . . 4.58 cm  Boundary roughness . .  0.97 cm
 Minimum . . . . 3.60 cm  Roughness type . . . .  Physical
 Average . . . . 4.09 cm
------------------------------------------------------------------------
AIN SIZE
 Mode . . .    1 to 2 phi   Range . . . . .    2 to 3 phi
------------------------------------------------------------------------
PARENT RPD
 Minimum . . . . Indet     Width . . . Indet
 Maximum . . . . Indet     Area  . . . Indet
 Average . . . . Indet
------------------------------------------------------------------------
DOX REBOUND LAYER
 Top . . . . . . 0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
------------------------------------------------------------------------
JD CLASTS
 Number. . . . . 0          Size  . . .  0.00 cm   Status . .  x
------------------------------------------------------------------------
ETHANE
 Minimum . . . .  0.00 cm   Number  . .  0
 Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
 Average . . . .  0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
 Depth . . . . .  4.58 cm
------------------------------------------------------------------------
OMMENTS
  Form comments:
  -0                 -DM > Pen          -Low Pen            -0
  -0                 -Bed Forms         -0                  -0
  -0                 -0                 -0                  -0
  -0                 -0                 -0                  -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
      Iron oxide being deposited in situ at surface
------------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . Stage I
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . Indeterminate
========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay     Time . . . 0426        Date . . . . . 102391
Number  . . . . eca5      Frame  . . 1           Initials . . . FCE
Replicate . . . b         Roll . . . 1           Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  4.24 cm  Boundary roughness . .  1.02 cm
  Minimum . . . .  3.22 cm  Roughness type . . . .  Physical
  Average . . . .  3.73 cm
-----------------------------------------------------------------------
RAIN SIZE
  Mode . . .    2 to 3 phi  Range . . . . .    2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  0.59 cm  Width . . . 13.73 cm
  Maximum . . . .  1.31 cm  Area  . . . 13.09 cm2
  Average . . . .  0.95 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm  Bottom  . .  0.00 cm  Width  . .  0.00 cm
-----------------------------------------------------------------------
IUD CLASTS
  Number  . . . .  0        Size  . . .  0.00 cm  Status . .  x
-----------------------------------------------------------------------
IETHANE
  Minimum . . . .  0.00 cm  Number  . .  0
  Maximum . . . .  0.00 cm  Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
DREDGED MATERIAL
  Depth . . . . .  4.24 cm
-----------------------------------------------------------------------
COMMENTS
  Form comments:
  -0                 -DM > Pen          -Low Pen          -0
  -0                 -0                 -0                -0
  -0                 -0                 -0                -0
  -0                 -0                 -0                -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
      stage two retrograde
-----------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . Stage II
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . 5
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0449       Date . . . . . 102391
Number  . . . . eca7       Frame  . . 1          Initials . . . FCE
Replicate . . . b          Roll . . . 1          Plan view  . . NO
-------------------------------------------------------------------------
IETRATION
Maximum . . . . 4.36 cm   Boundary roughness . .  0.25 cm
Minimum . . . . 4.11 cm   Roughness type . . . .  Biological
Average . . . . 4.24 cm
-------------------------------------------------------------------------
AIN SIZE
Mode . . .    2 to 3 phi   Range . . . . .     2 to 4 phi
-------------------------------------------------------------------------
PARENT RPD
Minimum . . . . Indet      Width . . . Indet
Maximum . . . . Indet      Area  . . . Indet
Average . . . . Indet
-------------------------------------------------------------------------
DOX REBOUND LAYER
Top . . . . . . . 0.00 cm   Bottom . . .  0.00 cm   Width  . .  0.00 cm
-------------------------------------------------------------------------
D CLASTS
Number  . . . .  0          Size  . . .  0.00 cm   Status . .  x
-------------------------------------------------------------------------
THANE
Minimum . . . .  0.00 cm   Number  . .  0
Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
Average . . . .  0.00 cm
-------------------------------------------------------------------------
REDGED MATERIAL
Depth . . . . .  4.36 cm
-------------------------------------------------------------------------
OMMENTS
Form comments:
-0                -DM > Pen           -0                  -0
-0                -0                  -0                  -0
-Poor Sort        -0                  -0                  -0
-0                -0                  -0                  -0

Add measure . .  0.00 cm   Comment: x

General comment:
    fish, plant debris on surface
-------------------------------------------------------------------------
IOLOGICAL
Successional stage . . . . . INDET
Low DO present . . . . . . . YES
Organism Sediment Index  . . Indeterminate
=========================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0513       Date . . . . . 102391
Number . . . . fdb1        Frame . . . 1         Initials . . . FCE
Replicate . . . a          Roll . . . 1          Plan view . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  5.17 cm   Boundary roughness . .  0.04 cm
  Minimum . . . .  5.13 cm   Roughness type . . . .  Physical
  Average . . . .  5.15 cm
-----------------------------------------------------------------------
AIN SIZE
  Mode . . . . 2 to 3 phi   Range . . . . . .  2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  1.06 cm   Width . . . 13.81 cm
  Maximum . . . .  2.54 cm   Area  . . . 24.87 cm2
  Average . . . .  1.80 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm   Bottom . .  0.00 cm   Width . .  0.00 cm
-----------------------------------------------------------------------
JD CLASTS
  Number . . . .  0          Size . . .  0.00 cm   Status . .  x
-----------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm   Number . .  0
  Maximum . . . .  0.00 cm   Size . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . .  5.17 cm
-----------------------------------------------------------------------
OMMENTS
  Form comments:
  -0               -DM > Pen        -0               -0
  -0               -0               -0               -0
  -Poor Sort       -0               -0               -0
  -0               -0               -0               -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
      x
-----------------------------------------------------------------------
IOLOGICAL
  Successional stage . . . . . Stage I
  Low DO present . . . . . . . NO
  Organism Sediment Index . . 4
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay      Time . . . 0543        Date . . . . . 102391
Number  . . . . fdb2       Frame  . . 1           Initials . . . FCE
Replicate . . . c          Roll . . . 1           Plan view  . . NO
-----------------------------------------------------------------------
ENETRATION
  Maximum . . . .  5.04 cm   Boundary roughness . .  0.34 cm
  Minimum . . . .  4.70 cm   Roughness type . . . .  Biological
  Average . . . .  4.87 cm
-----------------------------------------------------------------------
RAIN SIZE:
  Mode . . . .   2 to 3 phi   Range . . . . .    2 to 4 phi
-----------------------------------------------------------------------
PPARENT RPD
  Minimum . . . .  0.68 cm   Width . . . 13.73 cm
  Maximum . . . .  1.69 cm   Area  . . . 16.29 cm2
  Average . . . .  1.19 cm
-----------------------------------------------------------------------
EDOX REBOUND LAYER
  Top . . . . . .  0.00 cm   Bottom  . .  0.00 cm   Width  . .  0.00 cm
-----------------------------------------------------------------------
UD CLASTS
  Number  . . . .  0         Size  . . .  0.00 cm   Status . .  x
-----------------------------------------------------------------------
ETHANE
  Minimum . . . .  0.00 cm   Number  . .  0
  Maximum . . . .  0.00 cm   Size  . . .  0.00 cm
  Average . . . .  0.00 cm
-----------------------------------------------------------------------
DREDGED MATERIAL
  Depth . . . . .  5.04 cm
-----------------------------------------------------------------------
COMMENTS
  Form comments:
  -0                 -DM > Pen          -0                  -0
  -0                 -Bed Forms         -Mud/Sand           -0
  -Poor Sort         -0                 -0                  -0
  -0                 -0                 -0                  -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
     x
-----------------------------------------------------------------------
BIOLOGICAL
  Successional stage . . . . . Stage I
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . 3
=======================================================================
```

SAIC REMOTS DATASHEET

```
Station . . . . elbay    Time . . . . 0623      Date . . . . . . 102391
Number  . . . . fdb7     Frame  . . 1           Initials . . . FCE
Replicate . . . a        Roll . . . 1           Plan view  . . NO
------------------------------------------------------------------------
NETRATION
  Maximum . . . . 7.33 cm   Boundary roughness . .  0.59 cm
  Minimum . . . . 6.74 cm   Roughness type . . . .  Biological
  Average . . . . 7.03 cm
------------------------------------------------------------------------
AIN SIZE
  Mode . . .    2 to 3 phi   Range . . . . .    2 to 4 phi
------------------------------------------------------------------------
PARENT RPD
  Minimum . . . . 1.74 cm   Width . . . 13.69 cm
  Maximum . . . . 3.43 cm   Area  . . . 35.37 cm2
  Average . . . . 2.58 cm
------------------------------------------------------------------------
DOX REBOUND LAYER
  Top . . . . . . 0.00 cm  Bottom  . .  0.00 cm   Width  . .  0.00 cm
------------------------------------------------------------------------
JD CLASTS
  Number  . . . . 0          Size  . . .  0.00 cm   Status . .  x
------------------------------------------------------------------------
ETHANE
  Minimum . . . . 0.00 cm   Number  . .  0
  Maximum . . . . 0.00 cm   Size  . . .  0.00 cm
  Average . . . . 0.00 cm
------------------------------------------------------------------------
REDGED MATERIAL
  Depth . . . . . 7.33 cm
------------------------------------------------------------------------
OMMENTS
  Form comments:
  -0              -DM > Pen          -0               -0
  -0              -0                 -0               -0
  -Poor Sort      -0                 -0               -0
  -0              -0                 -0               -0

  Add measure . .  0.00 cm   Comment: x

  General comment:
    x
------------------------------------------------------------------------
BIOLOGICAL
  Successional stage. . . . . . Stage I
  Low DO present . . . . . . . NO
  Organism Sediment Index  . . 5
========================================================================
```